Imitation Banana Essence is made up of a mixture of amyl acetate and butyric ether.

Imitation Apple Essence is composed of an alcoholic solution of amyl valerianate, sometimes called apple oil, C₆H₁₁C₅H₅O₂, prepared by mixing four parts of amyl alcohol with four of sulphuric acid, and adding

### COMPOSITION OF IMITATION ESSENCES

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<th>Nitrous Ether</th>
<th>Aldehyde</th>
<th>Acetic Ether</th>
<th>Propionic Ether</th>
<th>Butyric Ether</th>
<th>Valerianic Ether</th>
<th>Propionic Glycol Ether</th>
<th>Oleic Ether</th>
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<th>Saturated Alcohol of Oil of Orange</th>
<th>Saturated Alcohol of Terminal Alcohols</th>
<th>Saturated Alcohol of Glycolic Acid</th>
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|            | Amyl Alcohol | Amyl-acetic Ether | Amyl-butyric Ether | Amyl-valerianic Ether | Oil of Lemon | Saturated Alcohol of Oil of Orange | Saturated Alcohol of Terminal Alcohols | Saturated Alcohol of Glycolic Acid | Saturated Alcohol of Hydrogenated Terminal Alcohols | Saturated Alcohol of Glycolic Acid | Saturated Alcohol of Hydrogenated Terminal Alcohols | Saturated Alcohol of Glycolic Acid | Saturated Alcohol of Hydrogenated Terminal Alcohols | Saturated Alcohol of Glycolic Acid | Saturated Alcohol of Hydrogenated Terminal Alcohols | Saturated Alcohol of Glycolic Acid | Saturated Alcohol of Hydrogenated Terminal Alcohols |
|------------|--------------|-------------------|--------------------|-----------------------|--------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| Pineapple  |              | 10                |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |                                  |
| Melon      |              | 3                 |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
| Strawberry |              | 3                 |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
| Raspberry  | 1             | 2                 |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
| Gooseberry |              | 1                 |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
| Grape      |              | 1                 |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
| Apple      |              | 10                |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
| Orange     |              | 1                 |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
| Pear       |              | 2                 |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
| Lemon      |              | 1                 |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
| Black cherry |          | 3                 |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
| Currant    |              | 1                 |                    |                       |             |                                |                                  |                                |                                  |                                |                                  |                                |                                  |                                  |                                  |                                  |                                  |
cleaned carefully, the refuse removed by shelling, paring, or other treatment, in most cases "blanched" (immersed in hot water for a period of time), and packed into cans. A weak brine to which has been added a little sugar in the case of corn, peas, etc., is added to vegetables and a syrup of various strengths to fruits. If the soldered can is used the cap is attached at this stage of the process, if the sanitary can, it is left open and "exhausted" at a temperature slightly below the boiling-point of water. In either case the process of sterilization is then carried out by heating in a saline solution or a dry retort at a suitable temperature above 100° C. The soldered can at this point is punctured to allow the escape of the compressed air, then closed with a drop of solder, while the sanitary can is sealed by double seaming on the cover using a special cement to insure tightness.

The canning of peas is fully described by Biting * and of other vegetables and fruits by Zavalla.†

Cooked vegetables and fruit products put up in glass jars or bottles are tightly sealed when hot, either with screw-caps or with some form of cover held by a clamp, or with metal or hard-rubber caps fitting over a flanged mouth. Commonly a soft-rubber ring is inserted between the cover and the mouth of the jar or bottle. The material of the cover is generally either glass, porcelain, or metal. Cork stoppers are, however, sometimes pressed into the mouths of the bottles, and made extra tight therein with sealing-wax. These stoppers are occasionally soaked in paraffin. Thus the contents of the jar may be exposed to porcelain, glass, metal, rubber, or cork, according to the material of the cover and the method of sealing.

The preservation of food by canning was long thought to be due to the perfect exclusion of air, but is now known to depend on the perfect sterilization, or destruction of bacteria, and it has been proved that as far as keeping qualities are concerned, it makes no difference whether or not air is present in the can, if the contents are sterile, though for purposes of inspection the vacuum, in the case of tin cans, is of great use, in that as a natural consequence of the vacuum, when the goods are sound, the ends of the cans are usually concave. The highest aim of the canner should be to retain in his product as far as possible the appearance, palatability, and nutritive value of the freshly cooked food.

Proximate Analyses of canned vegetables and fruits, as found on the market, have been made by various authors, and are useful in showing the food value of the products. The results in the table as given below are from Atwater and Bryant’s compilations. There is a lack of data on samples of known origin on which suitable standards may be based.

**PROXIMATE COMPOSITION OF CANNED VEGETABLES AND FRUITS.***

<table>
<thead>
<tr>
<th></th>
<th>No. of Analyses</th>
<th>Water</th>
<th>Protein</th>
<th>Fat</th>
<th>Total Carbohydrate</th>
<th>Crude Fiber</th>
<th>Ash</th>
<th>Per Value Found</th>
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<td>Artichoke</td>
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<td>110</td>
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<td>94.4</td>
<td>1.5</td>
<td>.1</td>
<td>2.8</td>
<td>.5</td>
<td>1.2</td>
<td>85</td>
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<td>Beans, baked</td>
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<td>68.9</td>
<td>6.9</td>
<td>2.5</td>
<td>10.0</td>
<td>2.5</td>
<td>2.1</td>
<td>600</td>
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<tr>
<td>&quot; string</td>
<td>29</td>
<td>93.7</td>
<td>1.1</td>
<td>.1</td>
<td>3.8</td>
<td>.5</td>
<td>1.3</td>
<td>95</td>
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<td>Lima, Lima</td>
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<td>79.5</td>
<td>4.0</td>
<td>.5</td>
<td>14.0</td>
<td>1.2</td>
<td>1.0</td>
<td>360</td>
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<td>1.5</td>
<td>.1</td>
<td>3.4</td>
<td>.5</td>
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<td>.9</td>
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<td>.2</td>
<td>4.0</td>
<td>.5</td>
<td>1.6</td>
<td>105</td>
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</table>

| **CANNED FRUITS.**   |                  |       |         |     |                   |             |     |                 |
| Apples, crab.      | 1               | 82.4  | .3      | 2.4 | 54.4              | .5          | .5  | 1,120           |
| Apple sauce        | 1               | 63.1  | .2      | .8  | 37.2              | .7          | .7  | 730             |
| Apricots           | 1               | 81.4  | .9      | .8  | 17.3              | .4          | .4  | 340             |
| Blackberries       | 1               | 40.0  | .8      | 2.1 | 56.4              | .7          | .7  | 1,150           |
| Blueberries        | 3               | 85.6  | .6      | .6  | 12.8              | .4          | .4  | 275             |
| Cherries           | 1               | 77.2  | 1.1     | .1  | 21.1              | .5          | .5  | 415             |
| Peaches            | 3               | 88.1  | .7      | .1  | 18.6              | .3          | .3  | 335             |
| Pears              | 4               | 81.2  | .3      | .3  | 18.0              | .3          | .3  | 335             |
| Pineapples         | 1               | 61.8  | .4      | .7  | 36.4              | .7          | .7  | 715             |
| Strawberries       | 1               | 74.8  | .7      | .7  | 24.0              | .5          | .5  | 400             |


The determination of the drained solids is often made with the view of detecting, especially in tomatoes, an excess of water added as such or as drainage from a better grade, but there are various unavoidable influences which affect the results. In addition to natural variations of canned tomatoes Bigelow * has shown that freezing, agitation during shipment, and other factors exert no little influence, while McGill † found as great variation in the different cans of the same brand as between the average of different brands. Obviously this determination is not applicable to canned vegetables such as pumpkin, which have little or no liquor.

DECOMPOSITION. — "Swells." — In the case of canned vegetables and fruit products, decomposition rarely results in the formation of ptomaines even after the can has long been open, though these toxins are sometimes formed in canned meat and fish. Spoilage is readily apparent after opening a can, from a cursory examination of its contents. The appearance, taste, and odor will not fail to indicate the unfitness of the contents for food, if decomposition is at all advanced. It is, however, often of great advantage to detect spoiled cans without opening. As a rule, when a can is spoiled, it is usually in the condition termed "blown," i.e., with its ends convex, instead of normal or concave.

Doremus * has shown that when the cans have become putrid carbon dioxide and hydrogen are the chief gases to be found.

According to Prescott and Underwood,† although nearly all forms of bacterial decomposition are accompanied by bulging of the ends of the cans, there are some exceptions. In the souring of canned sweet corn, which they trace to at least twelve varieties of bacteria, it is exceptional that swelling occurs. These "flat sours," are detected as follows: Boil the cans for an hour, causing the ends of all to swell, then cool, and set aside for eight hours, during which the sound cans will snap back, while the unsound will continue convex, by reason of the fact that the swelling in this case is due to the generation of gas by the bacteria present.

Ordinarily, in the factory inspection of canned goods before shipping, not only are the bulged cans or "swells," as they are termed, sifted out, but the condition of the cans is tested by sounding or striking the cans. If the contents are sweet, a peculiar note is produced when the can is struck, readily distinguishable from the dull tone of the unsound can by anyone familiar with the work.

"Springers" are cans which may appear normal in ordinary weather but have bulged ends on hot days. Baker,‡ who has made a special study of springers, has found that the gas present consists chiefly of carbon dioxide formed during processing, nitrogen from the air remaining after oxygen has combined with the tin or iron or else contents of the can, and usually hydrogen. He concludes that this abnormality may be largely obviated by avoiding over filling, closing the can while hot, thus producing a vacuum, avoiding delay in the process of canning, and using enameled cans for foods with high acidity.

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† Tech. Quart., 10, 1897, p. 183; 11, 1898, p. 6.
Bigelow * believes the hydrogen is formed by organic acids acting on the iron of the can, hence non-acid foods rarely form springers due to hydrogen. He further states that the three staples, tomatoes, peas, and corn, neither attack the metal considerably nor form springers from this cause. When the bulging is pronounced he advocates condemning the product because of the iron taste and the difficulty of distinguishing such springers from swells due to biological decomposition.

METALLIC IMPURITIES.—Salts of Lead and Tin are commonly met with in varying amounts in nearly all classes of products put up in tin. The quantity dissolved depends largely on the character of the tin plate used in the manufacture of the can, as well as on how the solder is applied. Much depends also on the nature of the food product and its acidity. Formerly much danger was apprehended from the use of the so-called terne plate as a material for cans. This consists of an alloy of lead and tin, coated on iron plate and intended for use as roofing. Sometimes two parts of lead to one part of tin are found in terne plate. Only the better grades of bright tin plate should be used in canning. There is reason to believe that no terne plate is at present used in cans. In 1892 the plating alloy of 47 samples of tin cans in which peas had been put up were examined in the Bureau of Chemistry of the U. S. Department of Agriculture,† and the amount of lead found varied from 0% to 13%. Only 4 samples were found to exceed 5%, and 24 contained less than 1%.

The construction of the can should be such that practically no soldered surface is exposed to the contents, the joints being lapped and soldered on the outside. In spite of this, however, it is not unusual to find cans soldered on the inside, or lumps of solder in the can from the sealing of the tapped hole. From 51% to 65% of lead was found in the solder taken from the interior of twenty-four of the cans mentioned in the preceding paragraph.‡

Cans lacquered on the inside to prevent contact of the metal with the food are coming into use but as yet are not an unqualified success. Some of the lacquers which have proved most efficient are objectionable because of their lead content.

Action of Fruits and Vegetables on Tin Plate.—A large variety of canned products have been examined in the laboratory of the Massachu-
setts State Board of Health, with a view to determining the quantity of tin contained in solution. The results have shown that though notable traces of tin were found in acid fruits and rhubarb, and large traces in some green vegetables, canned blueberries were found to contain, as a rule, much more tin in solution than any other canned goods examined. It is assumed that the tin was, at least in considerable part, still held in solution by the fruit acids, inasmuch as the metal was found in the filtered juice. In every instance the inner tin lining was found to be extensively corroded, and in some cases it had been almost entirely dissolved off, leaving the underlying iron bare. Fig. 119 shows the appearance of two of these cans, split open to show the inner surfaces. The corrosion is apparent. Eleven samples of canned blueberries, representing seven brands, were examined in 1894 by Worcester, showing an amount of tin solution (calculated as SnO₂) varying from 0.066 to 0.27 gram per can of 615-cc. capacity.

In 1899 samples of various canned products were examined for lead and tin in the author's laboratory, the results of which are thus summarized.*

VEGETABLE AND FRUIT PRODUCTS.

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<tr>
<td>Highest</td>
<td>Lowest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>.0102</td>
<td>.0011</td>
<td>615</td>
</tr>
<tr>
<td>Highest</td>
<td>Lowest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lima beans</td>
<td>.0064</td>
<td>.0004</td>
<td>650</td>
</tr>
<tr>
<td>Succotash</td>
<td>.0039</td>
<td>.0001</td>
<td>650</td>
</tr>
<tr>
<td>Squash</td>
<td>.0024</td>
<td>.0001</td>
<td>950</td>
</tr>
<tr>
<td>Highest</td>
<td>Lowest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asparagus</td>
<td>.1544</td>
<td>.0019</td>
<td>610</td>
</tr>
<tr>
<td>Rhubarb</td>
<td>.3509</td>
<td>.0002</td>
<td>615</td>
</tr>
<tr>
<td>Mutton broth</td>
<td>.0311</td>
<td>.0001</td>
<td>650</td>
</tr>
<tr>
<td>Tomato soup</td>
<td>.0093</td>
<td>.0002</td>
<td>375</td>
</tr>
<tr>
<td>Salmon</td>
<td>.0379</td>
<td>.0001</td>
<td>475</td>
</tr>
<tr>
<td>Lobster</td>
<td>.0431</td>
<td>.0001</td>
<td>450</td>
</tr>
</tbody>
</table>

A wide range of variation exists in the amount of tin dissolved. Pumpkin and squash, for example, dissolve surprisingly large quantities, considering the supposed inert nature of these vegetables.

In samples of canned sardines put up in mustard, vinegar, and oil, the Massachusetts Board has found as high as 0.376 gram of tin in a half-pound can. In these cases the corrosion of the interior of the cans was very marked.*

Effect of Time on Amount of Tin Dissolved.—A series of experiments was conducted by the author in 1899 † on the action of various fruit acids on tin, with a view to ascertaining, among other facts, whether or not the element of time exerts an appreciable difference in the results.

Samples of various canned fruits and vegetables were titrated for

* The U. S. Government, pending further investigation, permits 300 mg. of tin per kilo in canned goods. F. D. B. No. 126.
their acidity. It was found that certain samples of canned blueberries, for instance, had an acidity of about one-twentieth normal. In the case of strawberries, the acidity was about one-sixth normal. Canned raspberries were found to be about one-tenth normal in acidity, while the acidity of canned tomatoes varied from one-tenth to one-fourteenth normal. Solutions of one-fifth, one-tenth, and one-fifteenth-normal malic acid, one-tenth and one-fifteenth-normal tartaric acid, one-tenth and one-fifteenth-normal citric acid, and one-tenth-normal acetic acid were prepared and sealed in pint glass jars, having about the same capacity as the ordinary-sized tin fruit cans, each jar containing an amount of tin plate equivalent to the interior exposed surface of a can. Solutions thus sealed were kept for three months, six months, and a year, and examined at the end of these respective periods for tin. The results showing the amount of tin found at the end of three months in each case are given in the following list:

**ACTION OF FRUIT ACIDS ON TIN IN THREE MONTHS.**

<table>
<thead>
<tr>
<th>Acid</th>
<th>Grams of Tin in One Pint of Solution</th>
<th>Acid</th>
<th>Grams of Tin in One Pint of Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/5 malic</td>
<td>0.0576</td>
<td>N/15 tartaric</td>
<td>0.0246</td>
</tr>
<tr>
<td>N/10 &quot;</td>
<td>0.0201</td>
<td>N/10 citric</td>
<td>0.0274</td>
</tr>
<tr>
<td>N/15 &quot;</td>
<td>0.0107</td>
<td>N/15 &quot;</td>
<td>0.0236</td>
</tr>
<tr>
<td>N/10 tartaric</td>
<td>0.0382</td>
<td>N/10 acetic</td>
<td>0.0019</td>
</tr>
</tbody>
</table>

It was found that, as a rule, the amount dissolved in three months was the same as in six months or even a year.

Tenth-normal acetic acid sealed in jars with tin plate, as in the case of the fruit acids, dissolved in three months 0.0019 gram, and in six months 0.0083 gram of tin, which is much less than was obtained with fruit acids of the same strength, and with the samples of sardines referred to on page 263.

Bigelow and Bacon find that shrimps contain monomethylamin, which corrodes the cans in which they are packed. Their experiments with volatile alkalies and amino acids present in vegetables of low acidity indicate that the corrosive action of certain vegetables is due to substances of this group.

**Influence of Different Weights of Tin Coating.**—A committee of the National Canners Association, the American Sheet and Tin Plate Company, and the American Can Company has reported results of extensive experi-
ments on the action of various canned foods on cans with tin plate coatings of from 0.9 to 3.0 pound of tin per base box. Determinations of tin and iron were made at intervals. The figures in the following table show the extreme amounts of tin dissolved from the lowest and highest weights of plate and during short and long periods. The amounts of iron dissolved were more nearly uniform, the maximum being 90 mg. per kilo.

TIN IN CANNED VEGETABLES AND FRUIT

<table>
<thead>
<tr>
<th></th>
<th>StringBeans</th>
<th>Corn</th>
<th>Peas</th>
<th>Pumpkin</th>
<th>Tomatoes</th>
<th>Apples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packed 14-15 mo.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9-lb. plate...</td>
<td>97</td>
<td>75</td>
<td>13</td>
<td>3</td>
<td>32</td>
<td>9</td>
</tr>
<tr>
<td>3-lb. plate.....</td>
<td>161</td>
<td>126</td>
<td>14</td>
<td>3</td>
<td>27</td>
<td>15</td>
</tr>
<tr>
<td>Packed 104-13 mo.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.9-lb. plate...</td>
<td>220</td>
<td>154</td>
<td></td>
<td></td>
<td>26</td>
<td>12</td>
</tr>
<tr>
<td>3.0-lb. plate...</td>
<td>338</td>
<td>174</td>
<td></td>
<td></td>
<td>26</td>
<td>14</td>
</tr>
</tbody>
</table>

The committee in its conclusion states: "The lustre and the resistance to rusting increase somewhat with increased weight of coating. In other respects, with the exception of some instances in those classes of foods that have a tendency to perforate, the conclusion from this work is that the value of different weights of tin coating on food containers is for all practical purposes the same with average weights of from 1 to 3 pounds of tin per base box."

Salts of Lead.—While it is a fact that the material of the tin plating usually found in cans is comparatively low in lead, the same is not always true of the metal caps used to cover some of the bottled goods. The French "haricots verts" are usually sold in wide-mouthed bottles, closed by a disk of very soft metal. In one instance this metal cap, which came in contact with the liquid contents of the bottle, was found to contain 93.4% of lead. Of the various kinds of bottles in which are sold cheap carbonated drinks known as "pop," one style has a stopper consisting of a metallic button surrounded by a rubber ring. These metallic buttons consist of tin and lead in varying proportions. Inasmuch as the inclosed liquor was usually found to be quite acid in reaction, the danger of prolonged contact with the metallic portion of the stopper is evident.

The following table gives the percentage of lead found in the stoppers
of this character, together with the amount of lead contained in the liquor.*

<table>
<thead>
<tr>
<th>Character of Sample</th>
<th>Per Cent of Lead in Stopper</th>
<th>Amount of Lead in Contents of Bottle in Milligrams†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood orange</td>
<td>50.7</td>
<td>0.31</td>
</tr>
<tr>
<td>Birch beer</td>
<td>35.0</td>
<td>Large trace</td>
</tr>
<tr>
<td>Ginger</td>
<td>32.9</td>
<td>0.40</td>
</tr>
<tr>
<td>Strawberry A</td>
<td>8.8</td>
<td>0.30</td>
</tr>
<tr>
<td>Strawberry B</td>
<td>6.5</td>
<td>0.19</td>
</tr>
<tr>
<td>Sarsaparilla A</td>
<td>8.5</td>
<td>0.17</td>
</tr>
<tr>
<td>Sarsaparilla B</td>
<td>3.5</td>
<td>0.27</td>
</tr>
<tr>
<td>Lemon</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>Miscellaneous (20 samples)</td>
<td></td>
<td>1.05</td>
</tr>
<tr>
<td>Maximum</td>
<td>50.1</td>
<td>0.01</td>
</tr>
<tr>
<td>Minimum</td>
<td>3.8</td>
<td></td>
</tr>
</tbody>
</table>

† Capacity of bottle about ½ pint.

Besides the above tabulated samples, twenty were found with stoppers containing less than 3% of lead. While the amount of lead found in the contents of the bottles was in no case very large, it was enough to condemn the use of lead in the manufacture of such stoppers. That the amounts of lead found in the contents of the bottles vary quite irrespective of the percentage of lead in their stoppers, may be ascribed to various causes, such as the difference in the acidity of the liquors, and the length of time that the liquor has been in contact with the stopper. Furthermore, the more soluble metal of an alloy is attacked by an acid with an energy which is not proportional to the percentage of that metal in the alloy.

Salts of Zinc.—The presence of zinc salts in canned foods is largely accidental, and is generally due either to the contact of the acid fruits and vegetables with galvanized iron in the canneries, to the occasional use of brass vessels, or to the zinc chloride used as a soldering fluid. Higgard and Colby† have examined empty tin cans fresh from the manufacturer, and found zinc chloride in notable quantity in the seams, and especially in the empty space of the lap at the bottom of the can, where it could easily be acted on by the contents. The average amount of soluble zinc chloride found in the “lap” alone amounted to three-fourths of a grain per can. It was furthermore ascertained that it was not the practice of canners to wash the cans before packing, so that zinc present in canned goods may thus readily be accounted for.

Zinc chloride is commonly used in machine soldering, but should be
 displaced by rosin.

Holgard and Colby found in some spoiled cans of asparagus, where
the acidity was unusually high, an average of 6.3 grains of zinc chloride
per large can.

Zinc salts are said to have been used for greening peas, but their use
for this purpose is not common. Zinc chloride is the salt used, and a
natural yellowish-green tint is imparted when properly applied. The
process has been kept secret.

Salts of Copper.—While copper in canned goods is sometimes acci-
dental, its presence being due to the use of copper or brass vessels in the
canneries, its chief interest to the food analyst lies in the use of copper
sulphate for greening peas and other vegetables. The artificial greening
of vegetables is much more commonly practiced in France than in the
United States.

French canners of peas, beans, Brussels sprouts, etc., are frequently
so lavish in the use of sulphate of copper that the goods as found on our
markets can in some cases hardly be said to resemble the freshly cooked
products in color. Oftentimes, indeed, they possess such a deep green
as to be positively distasteful to the average American palate, though
evidently this unnatural hue is craved in Europe. The use of copper
in such foods is often rendered apparent by the most cursory examination.

In this country the use of copper was commonly in smaller amounts
than in France even before regulations prohibiting its use were adopted.

Complaint in court for this form of adulteration under the general
food law as it exists in most states would naturally be brought under one
of two clauses:

1st. As being colored, whereby the product appears of greater value
than it really is, or

2d. As containing an ingredient injurious to health.

An ingenious claim is sometimes advanced by the defendant in oppo-
sition to clause 1, to the effect that copper sulphate is added, not to give
an artificial green color, but to preserve the original green of the chloro-
phyll or natural color of the fresh peas,* so that it will not be destroyed
by subsequent boiling.

This point was argued in a strongly contested court case brought in
Massachusetts for copper in French peas.†

* The term used by the French to describe this process is reverdissage or "regreening."
As Worcester * has shown, the fallacy of this argument can be easily demonstrated. If it were true that the copper acts as a preservative of the chlorophyll, a pure extract of chlorophyll should, by the addition of copper sulphate, be prevented from destruction on boiling, and again, on once destroying the color of the chlorophyll by boiling, it would be impossible to restore it by further boiling it with copper sulphate.

As a matter of fact, if an extract of chlorophyll is boiled with a dilute solution of copper sulphate, its color is at once destroyed, and a brown precipitate is thrown down. On the other hand, if yellow or white peas or beans devoid of chlorophyll are boiled with copper sulphate, they are colored green, the depth of color depending on the strength of the copper solution. When peas or other vegetables are thus colored, very little copper is found, as a rule, in the liquid contents of the can, but the copper is chiefly confined to the solid portions. Green compounds are produced by boiling albumins with copper salts, due to the formation of albuminate, or in the case of peas, leguminate of copper. Harrington † states that it is possible to color eggs an intense green by boiling with copper sulphate.

Examination of a large number of brands of canned vegetables greened by copper, as bought in Massachusetts, showed that the amount used varied from a trace to 2.75 grams per can, calculated as copper sulphate. In justice to the consumer, who may be cautious about taking into his system copper salts, as well as to those who are indifferent to their use, it is no more than fair that all cans should have a label, plainly stating the quantity present. In the Massachusetts market, labels like the following are not uncommon: “This package of French Vegetables contains an equivalent of Metallic Copper not exceeding three-quarters of a grain.”

Copper as a coloring matter has been most commonly found in peas, beans, and Brussels sprouts. Copper salts in minute quantity have been found in Massachusetts in canned tomatoes, clams, and squash, as well as in pickles.

Salts of Nickel.—Sulphate of nickel has been employed instead of sulphate of copper for greening vegetables. According to Harrington † 0.25 gram of nickelous sulphate per kilogram of peas is used. The peas or other vegetables are boiled in a solution of the salt, made slightly alkaline with ammonia.

† Practical Hygiene, p. 203.
‡ Ibid., p. 205.
Zinc chloride is commonly used in machine soldering, but should be displaced by rosin.

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* The term used by the French to describe this process is *reverdisage* or "regreening.
"SOAKED GOODS."—It has become quite common, especially in the case of peas, beans, and corn, to utilize for canning purposes those that have grown old and dried, after soaking them for a long time. The presence of soaked peas in the market is generally more common in years when there is a scarcity in the pea crop. By the process of soaking, dried and matured field corn may be softened to such an extent as to be substituted for green or sweet corn in the canned product. These goods, frequently sold at a very low price, under some such tempting name as "Choice Early June Peas," are entirely devoid of that succulent property so highly prized in the fresh goods, and are altogether so inferior in quality that their sale may justly be considered as fraudulent, unless their character is specified. In some states the law provides that such a product, to be legally sold, shall have plainly marked on the label of the can the words "Soaked Goods" in letters of prescribed size.

Detection.—Methods of detecting soaked goods are distinctly physical rather than chemical. While chemical analysis may not be decisive, the appearance and taste of the goods furnish in most cases an unmistakable clue to their nature. Soaked goods are entirely lacking in juiciness, and in the flavors so characteristic of the various vegetables, when gathered and canned before becoming dry. The process of soaking is also said to develop the growth of the rudimentary stem of the embryo in the dried pea and bean. Peas and beans of the soaked variety are almost entirely lacking in the green color of the fresh vegetables, unless the color has been artificially supplied. The liquid is commonly milky.

In all cases it will be found that the solid grains or kernels of the peas, beans, and corn that have once been dried, though softened by the process of soaking, have much less water than the grains of the corresponding vegetables that were gathered while still soft and succulent.

METHODS OF ANALYSIS.

Methods of Proximate Analysis.—These are essentially the same as for cereal products with such variation in the preparation of the sample as is necessitated by the moist condition and lack of uniformity.

Examination of Gases from Spoiled Cans.—Fig. 118 shows the Doremus apparatus for puncturing the can with a hollow needle and conducting the gases into a eudiometer, where they are examined by the usual methods for gas analysis. Baker in his investigations used in conjunction with this apparatus a frame with another puncturing needle through which
water was introduced under pressure, thus forcing out all the gases through the Doremus needle.

**Determination of Drained Solids.**—Scarcely two workers have followed the same method. The results obtained depend on whether a sieve or cheese cloth is used for straining, the size of the mesh, the time allowed for draining, and whether or not any pressure is applied.

Magruder * uses a sieve with 1 mm. round holes and allows to stand for about five minutes, stirring gently with a spatula at the beginning and end.

McGill † turns out the contents of the can upon a piece of cheese cloth of known weight spread upon a sieve 6 inches in diameter and drains for approximately two hours without pressure or until drops fall at intervals of more than five seconds.

Ladd,‡ in addition to a ¼-inch mesh sieve adopted by the Canners' Associations of three states some years since, employs a cheese cloth to retain the finely divided matter, a method which, according to Bigelow's experiments,‡ gives 3% to 6% more drained solids than the sieve alone.

Determinations of Tin on Tin Plate.—Baker Method.*—Cut 4 square inches of the plate, loosely fold, introduce into a 300-cc. Erlenmeyer flask with from 50 to 100 cc. of concentrated hydrochloric acid, and determine the tin by the method as described for contents (p. 875), using, however, an iodine solution of such strength that, with the size of sample employed, 10 cc. is equivalent to 1 pound of tin per base box.

For the preparation of the iodine solution, dissolve 45 grams of iodine and 65 grams of potassium iodide in a small amount of water, dilute to 4 liters, allow to stand overnight, check against solutions containing a known amount of tin and an amount of iron equivalent to that used in a sample, and dilute until 1 cc. = 0.005786 gram tin.

Hiltner Method.†—This is a rapid method for the determination of lead as well as tin in both tin and tinne plate.

Determination of Lead in Tin Alloy.—Method of Paris Municipal Laboratory.‡—The material, if soft, is hammered into a thin plate, and 2½ grams are weighed out, transferred to a 250-cc. flask, and dissolved in 7 to 8 cc. of concentrated nitric acid. Evaporate to dryness on the sand-bath, add 10 drops of nitric acid and 50 cc. of boiling water, cool, and make up to 250 cc. with water. Let the residue settle and pour off through a filter 100 cc. of the clear, supernatant liquid, corresponding to 1 gram of the material. This contains the lead, while the tin is left behind in the residue, together with antimony if present.

Add 10 cc. of a standard solution of potassium bichromate (7.13 grams to the liter) and shake. Each cubic centimeter of this standard solution is sufficient to precipitate 0.01 gram of lead. Allow the lead chromate formed to settle, and, if the solution is colorless, add 10 cc. more of the bichromate, or sufficient to be present in excess, as indicated by the yellow color. Filter, wash, and titrate the excess of bichromate with a standard iron solution, containing 57 grams of the double sulphate of iron and ammonia and 125 grams of sulphuric acid per liter. This iron solution should be kept under a layer of petroleum, and standardized against the potassium bichromate before use.

Add, drop by drop, the iron solution to that containing the excess of bichromate. The color of the latter passes from pale green to bright green, when the chromate is completely reduced. Determine the end-

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† Western Chem. Metal., 4, 1908, p. 262.
VEGETABLE AND FRUIT PRODUCTS.

point with a freshly prepared dilute solution of potassium ferricyanide, a drop of which is placed on a porcelain plate or tile in contact with a little of the solution titrated. A blue color is produced when the iron is present in excess. If the standard iron and bichromate solutions exactly correspond, 1 cc. of the iron solution is equivalent to 1% of lead, but the latter solution is usually a little weak.

If \( n \) = number of cubic centimeters of iron solution necessary to reduce 10 cc. of the standard bichromate,

\[
1 \text{ cc. of the iron solution} = \frac{10}{n}.
\]

If, now, \( r \) = number of cubic centimeters of iron solution necessary to reduce the excess of bichromate in the determination, and \( s \) = number of cubic centimeters of bichromate used,

\[
s - \frac{10}{n} = \text{per cent of lead in the alloy}.
\]

Separation and Determination of Tin, Copper, Lead, and Zinc in Canned Goods.—Munson’s Method.*—The contents of the can are first evaporated to dryness, and from 10 to 15 cc. of concentrated sulfuric acid or enough to carbonize are added to the dry residue contained in a porcelain evaporating-dish, which is very gently heated over the flame till foaming ceases. Then ignite to an ash in a muffle, or carefully over the free flame, using a little nitric acid, if necessary, for oxidation of the organic matter. Add 20 cc. of dilute hydrochloric acid, and evaporate over the water-bath to dryness. Wash the residue into a beaker, slightly acidify with hydrochloric acid, and saturate with hydrogen sulphide without previous filtration. Heat the beaker on the water-bath, and pass the contents through a filter. Wash the precipitate, which contains sulphides of tin, lead, and copper, if these metals are present, while if there is zinc, it is contained in the filtrate. The precipitate is fused with sodium hydroxide in a silver crucible for half an hour, to increase the solubility of the tin, which would otherwise be dissolved with difficulty. The fusion is boiled up with hot water, acidulated with hydrochloric acid, and transferred without filtering to a beaker, in which hydrogen sulphide is added to saturation. This precipitates the sulphides of tin, lead, and copper (if these metals are present). The sulphide precipitate is collected

on a filter, and thoroughly washed with hot water, the washings being
rejected. Pass through the filter several portions of boiling ammonium
sulphide, using about 50 cc. in all, or till all the tin is dissolved. Precipi-
tate the tin from the combined filtrate with hydrochloric acid, filter,
wash, ignite, and weigh as stannic oxide.

The residue left on the filter, after dissolving out the tin sulphide, is
then dissolved by treatment with nitric acid, which is filtered, and to
the filtrate and washings ammonia is added nearly to the point of neutral-
ization. Then add ammonium acetate. Filter off any precipitate of
iron that may be formed. The filtrate is divided into two portions for
determination of copper and lead. If lead is absent, determine the
copper by titration with potassium cyanide* or electrolytically (p. 634).
Copper is rarely present in sufficient amount to be determined, unless
used for greening the vegetables. If notable quantities of lead are present,
the solution is made acid with acetic, and the lead precipitated therefrom
with potassium chromate, collected on a tared filter, washed with water
acidified with acetic acid, dried at 100° C., and weighed as lead chromate.
Or determine the lead by color-tests, as on page 362.

For the determination of zinc, the filtrate from the first hydrogen-
sulphide residue is evaporated to a volume of about 60 cc., and treated
with bromine water to oxidize the iron, as well as any excess of hydrogen
sulphide remaining, the excess of bromine is then boiled off, and a few
drops of concentrated ferric chloride added, to make the solution distinctly
yellow, if not already so. Nearly neutralize with ammonia, and precipi-
tate the iron with ammonium acetate. Filter, wash, acidify the filtrate
with acetic acid, and precipitate the zinc with hydrogen sulphide. Filter,
wash, ignite, and weigh as zinc oxide.

The metals may be determined separately, as follows:

**Determination of Tin.**†—Evaporate the contents of the can to dry-
ness, and ignite in porcelain. Fuse the ash with sodium hydroxide in a
silver crucible, boil the fusion with several portions of water acidulated
with hydrochloric acid, filter, and precipitate the tin from the acid solu-
tion with hydrogen sulphide. Dissolve the washed precipitate in ammo-
nium sulphide, filter, and deposit the tin directly from this solution by
electrolysis in the platinum dish which contains it, using a current of
0.5 ampere and the electrolytic apparatus described on page 634.

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* Sutton, Volumetric Analysis, 8th ed., p. 204.
State Board of Health, 1899, p. 635.
Smith and Bartlett* employ the following method of solution: Weigh 50 grams of fish or 100 grams of vegetables in a porcelain dish and dry overnight. Heat from 75 to 100 cc. of concentrated sulphuric acid in a Kjeldahl flask until acid fumes are visible, then add gradually small portions of the food product, heating the acid between additions until frothing ceases. Allow to cool, then add gradually to the charred mixture 25 cc. of concentrated nitric acid, which causes the evolution of red fumes and the generation of heat. Cool, add 25 cc. of nitric acid and heat gently until all nitric fumes are expelled and the charred material is dissolved to a homogeneous solution. Boil this solution about forty-five minutes, then add from 10 to 15 grams of potassium sulphate and continue boiling from three to five hours until decolorized. Wash the digest into an 800-cc. beaker, dilute to about 600 cc. and bring to a boil. Almost all of the tin separates as stannic oxide, partially hydrated, some of which adheres to the sides of the flask, and cannot be removed by washing. Filter the contents of the beaker, thus separating the hydrated stannous oxide from all other compounds. Place the filter in the flask, to which 20 cc. of saturated sodium hydroxide and an equal volume of water have been added, boil for several minutes, then wash the sodium stannate into a beaker. Acidify with hydrochloric acid, precipitate with hydrogen sulphide, and proceed as above described.

Hanson and Johnson† heat a quantity of the material, containing about 25 grams of solids, with a mixture of 200 cc. of water, 100 cc. of concentrated nitric acid and 50 cc. of concentrated sulphuric acid, adding additional nitric acid from time to time and finally 25 grams of potassium sulphate.

Baker Method.‡—Treat 100 grams of the material with nitric and sulphuric acid as described in the preceding sections. Dilute the sulphuric acid residue, neutralize with ammonia, add hydrochloric acid until the solution contains about 2%, and thoroughly saturate with hydrogen sulphide gas. Filter the impure lead sulphide on a Gooch crucible with a false bottom, wash three or four times with water, then transfer precipitate and asbestos to a 300-cc. Erlenmeyer flask, washing with a little water, and boil with strong hydrochloric acid, adding potassium chlorate from time to time to insure complete solution of the tin sulphide as well as the elimination of the sulphur. Add a few strips of pure aluminum foil.

free from tin, until all the chlorine is eliminated, then dilute to from 30% to 40% acid strength and attach to a carbon dioxide generator provided with a scrubber and charged with pure marble and hydrochloric acid.

A bulb tube passing through one opening of a double-bore stopper serves to deliver the gas near the surface of the liquid and another bulb tube provides an exit, the latter being connected with a glass tube immersed in water to the depth of 20 cm., forming a water seal. When the flask is first attached to the carbon dioxide apparatus, lift the exit tube out of the water so as to reduce the pressure and thus force a large amount of gas through the system, expelling all air. Then raise the stopper of the flask and introduce about 1 gram of aluminum foil, which quickly reduces the tin to the metallic form with evolution of hydrogen.

Heat to boiling on a hot plate and boil for a few minutes, which causes the aluminum to disappear and changes the tin into stannous chloride, then cool in ice-water, still passing carbon dioxide through the system. Remove the stopper together with the tubes, washing the same and the sides of the flask with air-free water, prepared by boiling distilled water, adding a small amount of sodium bicarbonate and then a slight excess of hydrochloric acid.

Add starch paste and titrate directly and quickly with hundredth-normal iodine solution until a faint blue color is obtained. The iodine solution is standardized against pure tin solution or a food mixture, such as apple butter, containing an added amount of tin salt.

An alternate procedure is to add an excess of iodine solution to the flask after lifting the stopper, but while the carbon dioxide is still issuing from the neck, and titrate the excess with standard sodium thiosulphate solution.

By means of a Y-tube the current from one generator may be divided for two flasks so that duplicates may be conducted at the same time.

**Determination of Lead**, especially applicable if lead is present in small amounts only. Boil the sulphated ash of the contents of the can (obtained as on page 973) with a solution of ammonium acetate, having an excess of ammonia. The tin, zinc, and iron remain insoluble, while the copper and lead are dissolved. Filter, wash, and add a few drops of potassium cyanide to the filtrate, to prevent precipitation of copper when hydrogen sulphide is subsequently added. If the solution exceeds 40 cc., concentrate to that amount by evaporation, and transfer to a 50-cc. Nessler tube. Add hydrogen sulphide water, and make up to the mark. Compare the brown color imparted by the lead sulphide, with the colors obtained
by treating with hydrogen sulphide water in Nessler tubes various measured amounts of a standard solution of lead acetate, made alkaline with ammonia. See also page 362.

**Determination of Copper.**—(1) *Electrolytically.*—Ash the contents of the can as on page 973. Wet the ash with concentrated nitric acid, add water, and boil. Then make strongly alkaline with ammonia and filter. Unless the filtrate is colored blue, copper is absent. Transfer the filtrate to a bright tared platinum dish of 100-cc. capacity, neutralize with concentrated nitric acid, and add about 2 cc. in excess. Nearly fill the dish with water, and electrolyze with the apparatus described on page 634, using a current of about 0.3 of an ampere.

(2) *Colorimetrically.*—This method is especially applicable for small amounts of copper. The blue-colored ammoniacal solution of the ash, filtered as in (1), is transferred to a Nessler tube, and its color matched against the colors of a series of measured amounts of an ammoniacal standard solution of copper sulphate.

**Determination of Nickel.**—Boil the ash with water slightly acidified with hydrochloric acid, and without filtering, saturate with hydrogen sulphide, thus precipitating out any copper, tin, or lead. Filter and wash. Zinc and nickel, if present, are in the filtrate. Boil the filtrate to expel the hydrogen sulphide, and add sodium carbonate till slightly alkaline. Add acetic acid without filtering till the precipitate produced by the alkaline carbonate is dissolved, and then add a considerable excess of acetic acid. The zinc is precipitated by passing hydrogen sulphide through the cold dilute solution, while the nickel is held in solution by the large excess of acetic acid. Filter, and wash with hydrogen sulphide water, to which a little ammonium acetate has been added.

Make the filtrate alkaline with ammonia, precipitate the nickel with ammonium sulphide, filter, wash, ignite, and weigh as nickelous oxide.

**Ketchup.**

**Standards.**—The following are the United States standards:

*Catchup (Ketchup, Catsup)* is the clean, sound product made from the properly prepared pulp of clean, sound, fresh tomatoes, with spices and with or without sugar and vinegar; *Mushroom Catchup, Walnut Catchup*, etc., are catchups made as above described, and conform in name to the substances used in their preparation.

No standard is given for *Chili Sauce*, a product made from tomatoes,
peppers, onions, vinegar, sugar, and spices, differing from ketchup in that it is not strained.

**Process of Manufacture.**—When made in the household ripe tomatoes, with or without paring and coring, are cut in pieces and boiled down to a thick pulp, strained to remove seeds and other coarse tissues and finally heated for a time with vinegar, spices, salt, and sugar. The product is bottled while hot.

Factory-made ketchup, of good quality, is prepared by practically the same process, using special apparatus for washing, pulping and concentrating. In many factories considerable time elapses before the finishing processes are carried out, the pulp being stored in barrels or better in lacquered tin receptacles until needed. Manufacturers of ketchup often purchase the barrelled or canned pulp from canning factories, confining their attention to the final processes and bottling.

In the so-called gravity process the pulped material is allowed to stand until fermentation sets in and the cellular matter rises to the surface. The clear liquid is then removed from below. In Italy it is a common practice in the manufacture of tomato paste to allow the pulp to ferment for a time, after which the fermentation is checked by the addition of salt.*

**The Composition of Tomato Catsup** varies within wide limits due chiefly to variations in the composition of the tomatoes, the amount of fibrous material removed in screening, the degree of concentration, and the amount and composition of the substances added, particularly the vinegar. This is shown by the maximum and minimum results for total solids and acidity reported in commercial catsups by Winton and Ogden,† Street,‡ and McGill § as given in the following table:

<table>
<thead>
<tr>
<th>Total Solids</th>
<th>Acidity Calc. as Acetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winton and Ogden</td>
<td>42.64-6.03</td>
</tr>
<tr>
<td>Street</td>
<td>37.49-7.27</td>
</tr>
<tr>
<td>McGill</td>
<td>38.63-6.66</td>
</tr>
</tbody>
</table>

**Tomato Catsup from Trimmings.**—If instead of the pulp of the whole tomato the pulp of trimmings (skins, cores, etc.) from tomato canneries is

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* Daily Consular and Trade Reports, 14, 1911, p. 74.
‡ Ibid., Rep., 1910, p. 521.
used another complication is introduced. The presence of trimmings pulp obviously cannot be detected by mere determination of solids, even if no salt, sugar, or other additions were made, since the percentage of solids is dependent in large part on the degree of concentration. Bigelow and Fitzgerald* calculated the ratio of pulp solids to filtrate solids and the percentage of insoluble solids in the total solids, in the case of whole tomato pulp and of trimmings pulp with the following results:

<table>
<thead>
<tr>
<th></th>
<th>Whole Tomato Pulp.</th>
<th>Trimmings Pulp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratio of pulp solids to filtrate solids: Maximum.</td>
<td>1.154*</td>
<td>1.241†</td>
</tr>
<tr>
<td></td>
<td>Minimum.</td>
<td>1.001*</td>
</tr>
<tr>
<td>Per cent of insoluble solids in total solids: Maximum.</td>
<td>17.4‡</td>
<td>14.7§</td>
</tr>
<tr>
<td></td>
<td>Minimum.</td>
<td>9.8‡</td>
</tr>
</tbody>
</table>

* 30 samples. † 18 samples. ‡ 24 samples. § 7 samples.

These results do not sharply differentiate the two products and after the addition of the other constituents proper to tomato catsup the distinction would be still less marked or entirely absent.

The use of tomato trimmings for cheap catsup appears unobjectionable provided they are from sound tomatoes and have not been allowed to spoil. Too often the material is objectionable. This is especially the case when the product is improperly stored and too long a time elapses before its manufacture into catsup.

**Decayed Material.**—According to Bacon and Dunbar† fresh tomatoes contain on the average 6.5% total solids, of which 3.5% is invert sugar, 0.5% citric acid, 0.6% ash, 0.9% protein (N ¥ 6.25), 0.85% crude fiber and 0.05% fat. During spoilage the sugars rapidly disappear, forming alcohol, carbon dioxide, acetic and lactic acids, the amounts of each formed depending on the organisms present. Usually the citric acid is also decomposed. A good ketchup is accordingly characterized by a high citric acid content and little lactic acid, while one made from decomposed material will usually contain little or no citric acid, but a high percent of lactic acid.

Bitting and Bitting‡ state: "The procedure in determining wholesomeness is different from that for sterility, as in the former one must deal with

† U. S. Dept. of Agric., Bur. of Chem., Circ. 78.
the dead organisms, and is limited almost wholly to what may be seen under
the microscope. It is most unfortunate that no satisfactory method has
been developed to determine the presence of unfit material, as the pur-
chaser has no means of judging from looks, taste, or smell what may have
entered into these comminuted products. In the whole or large piece
stock, he can judge by the gross appearance with a fair degree of accuracy.
We are lacking in the fundamentals necessary for a proper examination:
that is what constitutes the normal flora upon fully matured products, the
abundance to which they attain under varying conditions, and what organ-
isms cause the changes which are generally recognized as decomposition.”

Howard in the examination of catsup under the federal law counts
(1) rod-shaped bacteria (but ignores micrococci), (2) yeast cells and yeast
and mold spores together (radically different bodies), and (3) number of
fields containing mold filaments exceeding one-sixth the diameter of the
field (i.e., determines the subdivision and distribution, rather than the
amount of filaments). Details are described in government publications;*
criticisms are given by Bitting and Bitting,† Prescott, Burrage, and Phil-
brick,‡ and Tanner.§

Foreign Pulp.—Pumpkin pulp and apple sauce, the latter made often
from unsound material or even pomace, have been extensively used in
cheap ketchups. At the present time such compound sauces are usually
labelled to show the constituents present.

Preservatives.—Salicylic acid, formerly used in most commercial
ketchup, more recently has given place to benzoate of soda. Bitting||
has shown that by using sound tomatoes and exercising proper care in
the process of manufacture, ketchup can be kept without a preservative.
Manufacturers themselves have corroborated this, many of the standard
brands being entirely free from any antiseptic material other than spices
and vinegar.

Artificial Colors.—Of ninety-four samples of ketchup examined in
1901 in Connecticut all but fifteen contained coal-tar colors.¶ This
practice, however, is now decreasing and is indeed quite unnecessary if

Circ., 68, 1911.
§ Bacteriology and Mycology of Foods, New York, 1919, pp. 515, 519.
VEGETABLE AND FRUIT PRODUCTS.

fresh ripe tomatoes are used, dark-colored spices are avoided, and sugar is not added until the end of the process.

METHODS OF ANALYSIS.

The methods described under this head, except those for solids by calculation, may be used for tomato catsup, chili sauce, tomato pulp, fresh tomatoes, and canned tomatoes, provided the material is suitably sampled.

**Determination of Specific Gravity.**—*Bigelow and Fitzgerald* * in order to remove air bubbles unavoidably introduced in pouring into the picrometer, centrifuge at 1000 revolutions per minute, add more of the material to volume, and repeat the centrifuging until there is no more contraction.

Ash, Alkalinity of Ash, and Sodium Chloride are determined by the methods described for jams and jellies (page 996). **Volatile Acids**, as acetic, is determined by the method described for vinegar (page 797). Tests for **Preservatives** and **Colors** are carried out as described in Chapters XV and XVI.

**Determination of Solids.**—Weigh 10 grams of the sample into a flat-bottomed metal dish 6 cm. in diameter, add water to distribute the material, evaporate to dryness, dry four hours at the temperature of boiling water, and weigh.

**Determination of Insoluble Solids.†**—Shake 20 grams of the material with hot water in a narrow cylinder, centrifuge and decant the clear liquid on a tared filter-paper and filter with the aid of suction. Repeat the operation several times, finally transferring the material to the paper. Finish the washing on the paper and dry at 100° C. to constant weight.

The filtering may be carried on to advantage on a Buchner funnel, using two or more tared filters, as the suction is liable to break a single layer.

**Determination of Sand.†**—Weigh 100 grams of the well-mixed sample into a 2- or 3-liter beaker, nearly fill the beaker with water, and mix the contents thoroughly. Allow to stand five minutes and decant the supernatant liquid into a second beaker. Refill the first with water and again mix the contents. After five minutes more decant the second beaker into a third, the first into the second, refill and again mix the first. Continue this operation, decanting from the third beaker into the sink until the

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lighter material is washed out from the ketchup. Then collect the sand from the three beakers into a tared Gooch crucible, dry, ignite, and weigh.

The method for the determination of ash insoluble in hydrochloric acid is not applicable to the determination of sand in tomato products, owing to the small amount and uneven distribution. Even when 100 grams are used the results are far from concordant.

**Determination of Soluble Solids.**—Subtract the percentage of insoluble solids from the percentage of total solids.

**Determination of Reducing Sugars.**—*Direct.*—Place 10 grams of the ketchup in a 100-cc. flask, add an excess of normal lead acetate, make up to the mark and filter. To the filtrate add powdered sodium sulphate or carbonate sufficient to precipitate the excess of lead and again filter. Determine the reducing powder of the filtrate by the Munson and Walker method (p. 622) and calculate as invert sugar.

**After Inversion.**—Mix 50 cc. of the solution, after clarifying and removal of the lead, as described in the last paragraph, with 5 cc. of concentrated hydrochloric acid, invert in the usual manner (p. 611), nearly neutralize with sodium hydroxide and determine the reducing power as before inversion.

**Determination of Acidity.**—*Bigelow and Fitzgerald Method.*—Dilute 20 grams of the material with at least 200 cc. of water, add 0.5 cc. of 1% phenolphthalein solution in alcohol, and titrate with N/10 sodium hydroxide solution. Add 1 cc. of N/10 hydrochloric acid, heat quickly to boiling, boil one minute to expel carbon dioxide, cool, and titrate back with the standard alkali.

One cc. of N/10 alkali is equivalent to 0.0064 gram of citric acid.

**Determination of Citric Acid.**—*Bacon and Dunbar Method.*—Weigh 25 grams into a 250-cc. beaker, make up to approximately 200 cc. with 95 per cent alcohol, allow to stand with frequent stirring for four hours, filter through a folded filter and wash with 50 cc. of 80% alcohol. To the filtrate add sufficient water to dilute the alcohol to 50% or 60% and then add 10 cc. of 20% barium acetate solution, stir well with a glass rod, and allow to stand overnight. In the morning filter on a Gooch crucible, washing with 50% alcohol, dry for from three to four hours in an oven at 100° C. and weigh. Weight of precipitate times 0.51 equals anhydrous citric acid. This method is not applicable in the presence of malic acid, hence if apple pulp is a constituent of the ketchup, the Pratt method (page 1009), should be employed.

* Loc. cit.
Determination of Lactic Acid.—Bacon and Dunbar Method.*—To 100 grams of ketchup add 10 cc. of 20% normal lead acetate solution, make up to 500 cc., shake well and centrifuge. To 400 cc. of the clear portion add a moderate excess of sulphuric acid, filter, wash the precipitate with a small amount of water, and evaporate the filtrate on the steam bath to about 100 cc. Extract for from eighteen to twenty hours in a liquid extractor (Fig. 120) with washed ether. In case the quantity of lactic acid present is greater than 0.5 gram it is usually necessary to extract for a longer period. In any case it is well to re-extract for from eight to ten hours to make sure that the extraction is complete. Ether sufficiently pure for this purpose may be prepared by shaking out ordinary ether once with a sodium hydroxide solution and then ten times with small quantities of water. Evaporate on a steam bath until the ether is no longer evident, and take up the residue at once in water and filter, thus removing a small amount of coloring matter and substances other than lactic acid, which may be extracted from ketchup by ether, but which are insoluble in water. Heat the filtrate on the steam bath for some time to remove all traces of ether or alcohol. Add approximately 3 grams of sodium hydroxide and 50 cc. of a 1.5% solution of potassium permanganate from a pipette. Heat on a water-bath at 100° C. for one-half hour. At the end of that time, or before, if the color is not a decided blue-black or purple, but is green or colorless above the layer of brown precipitate, add more standard permanganate until, after heating one-half hour on a boiling water-bath, the color is a blue-black or purple. The oxidation is then complete. Make the hot solution strongly acid with 10% sulphuric acid (about 50 cc.) and run in 5% standard oxalic acid from a burette until the solution is decolorized. Titrate back any slight excess of oxalic acid with the standard permanganate solution.

*Loc cit.
(Any standard permanganate and oxalic acid solution may be used within reasonable limits of strength.)

In alkaline solution the permanganate oxidizes the lactic acid quantitatively to oxalic acid according to the equation:

\[ 2C_2H_4O_2 + 10KMnO_4 = 2(COOH)_2 + 4H_2O + 2CO_2 + 5MnO_2 + 5K_2MnO_4. \]

Then in acid solution, the oxalic acid is further oxidized by the permanganate to carbon dioxide and water according to the equation:

\[ 5(COOH)_2 + 2KMnO_4 + 3H_2SO_4 = 10CO_2 + 8H_2O + K_2SO_4 + 2MnSO_4. \]

To determine the total weight of permanganate used in the oxidation of the lactic acid subtract the permanganate equivalent of the oxalic acid used from the total amount used. The weight of permanganate times 0.237 equals the weight of lactic acid.

**Microscopic Examination for Foreign Pulp.**—Apple is identified by the window-like cells of the skin, the pitted vessels of the bundles, quite unlike the vessels of the tomato, and the tissues of the core. Pumpkin may be detected by the yellow skin of the fruit with colorless stomata, somewhat obscure latex tubes and the peculiar cactus-like parenchyma of the seeds. Although only the fruit pulp is used, fragments of the skin and seeds of sufficient size to be of diagnostic importance often find their way into the product.

**PICKLES.**

A large variety of vegetables and fruits are preserved in the form of pickles in vinegar, either with or without spices, and kept in wooden pails, stoneware pots, kegs, or sealed wide-mouthed bottles. The containers are not of necessity air-tight. The commoner vegetables are usually pickled without cooking, while fruits such as peaches, pears, gooseberries, etc., are usually cooked, or at least heated. Analyses of pickles and relishes appear in the table, page 985.

*Cucumber Pickles* are the most common, and are prepared by soaking the fresh cucumbers in strong salt brine. They are then dried on frames, and afterwards treated with boiling vinegar, to which spices may or may not be added. Other vegetables pickled in similar manner, either separately or in mixture with cucumbers or "gherkins" to form "mixed pickles," are cauliflower, bean pods, white cabbage, young walnuts, and onions.
Determination of Lactic Acid.—Bacon and Dunbar Method.*—To 100 grams of ketchup add 10 cc. of 20% normal lead acetate solution, make up to 500 cc., shake well and centrifuge. To 400 cc. of the clear portion add a moderate excess of sulphuric acid, filter, wash the precipitate with a small amount of water, and evaporate the filtrate on the steam bath to about 100 cc. Extract for from eighteen to twenty hours in a liquid extractor (Fig. 120) with washed ether. In case the quantity of lactic acid present is greater than 0.5 gram it is usually necessary to extract for a longer period. In any case it is well to re-extract for from eight to ten hours to make sure that the extraction is complete. Ether sufficiently pure for this purpose may be prepared by shaking out ordinary ether once with a sodium hydroxide solution and then ten times with small quantities of water. Evaporate on a steam bath until the ether is no longer evident, and take up the residue at once in water and filter, thus removing a small amount of coloring matter and substances other than lactic acid, which may be extracted from ketchup by ether, but which are insoluble in water. Heat the filtrate on the steam bath for some time to remove all traces of ether or alcohol. Add approximately 3 grams of sodium hydroxide and 50 cc. of a 1.5% solution of potassium permanganate from a pipette. Heat on a water-bath at 100° C. for one-half hour. At the end of that time, or before, if the color is not a decided blue-black or purple, but is green or colorless above the layer of brown precipitate, add more standard permanganate until, after heating one-half hour on a boiling water-bath, the color is a blue-black or purple. The oxidation is then complete. Make the hot solution strongly acid with 10% sulphuric acid (about 50 cc.) and run in 5% standard oxalic acid from a burette until the solution is decolorized. Titrate back any slight excess of oxalic acid with the standard permanganate solution.

* Loc cit.
Adulteration.—Pickles were formerly greened in the household by the use of copper kettles and in the factory by the addition of copper sulphate. For methods of detection and estimation of copper, see page 634. Pickles may be greened by boiling with much less harmful substances than copper salts, such, for example, as grape leaves, spinach, or parsley.

Free Sulphuric Acid has been found in a number of cases in the vinegar of pickles bought on the Massachusetts market. A pronounced test for chloride with nitrate of silver should not be attributed to free hydrochloric acid, since it may be due to the salt from the brine in which the pickles have been treated.

Alum is sometimes added to the salt solution to produce hardness and crispness in pickles. A number of samples of cucumber pickles have been found by the author to contain alum. For its detection, fuse the ash of the pickles, if free from copper, in a platinum dish with sodium carbonate, extract with boiling water, filter, and add ammonium chloride. A flocculent precipitate shows alum.

Sodium Benzoate and Saccharin have been frequently detected in sweet pickles.

Horseradish.—This condiment is prepared by grating the root of the perennial herb Nasturtium armoracia, and preserving in vinegar. It is very pungent and aromatic when first prepared, but by exposure to light and air quickly loses strength. Turnip pulp is used as an adulterant.

PRESERVES.

Under this head are included various fruit products prepared with sugar syrup and often also with spices and vinegar. Some of these products differ little from canned fruits while others are really sweet pickles. Mince meat, although not strictly a fruit product, and fruits in cordials are classified for convenience as preserves. Jams are considered with jellies in the next section, as are also methods of analysis.

Fruit Butter.—According to the U. S. Standard, "fruit butter is the sound product made from fruit juice and clean, sound, properly matured and prepared fruit, evaporated to a semi-solid mass of homogeneous consistence, with or without the addition of sugar and spices or vinegar, and conforms in name to the fruit used in its preparation."

Apple Butter is the best-known product of this class. Unfortunately it is sometimes made from decayed fruit or even from apple pomace. Glucose is frequently substituted wholly or in part for sugar, in which case its presence should be declared on the label.
Mince Meat.—As prepared in the household, mince meat, the filling for mince pies, contains from 10 to 20% of lean meat and about twice as much apple. Other constituents appear in the following typical formula with statement of quantities in parts by weight: 2 parts each of meat, raisins, dried currants, and sugar, 4 parts of apples, 1 part each of suet and candied citron, 2 parts of sweet cider, wine or brandy, 1 to 2 parts of seasoning including salt, spices, and lemons or oranges.

Standard Mince Meat of the A.O.A.C. and the Association of State and National Dairy and Food Departments, "is a mixture of not less than 10% of cooked comminuted meat, with chopped suet, apple and other fruit, salt, and spices, and with sugar, syrup, or molasses, and with or without vinegar, fresh, concentrated, or fermented fruit juices, or spirituous liquors."

Adulteration.—There has been some conflict between food officials and certain manufacturers as to the proportion of meat in commercial mince meat, the manufacturers claiming that 10% is too much for the proper keeping of the product, the food officials, on the other hand, contending that the manufacturer has no right to lower the recognized standard of the housewife.

As a matter of fact the greater part of the mince meat on the market contains considerably less than 10% of meat and much of it none whatever. Glucose is a common substitute for part of the sugar, wormy or other inferior fruit is sometimes used, and benzoate of soda is added as a preservative.

Condensed Mince Meat is made in a commercial way from dried apples and other desiccated materials and is sold in compressed cakes with instructions for preparing from the cakes moist pie filling. As in the case of wet mince meat, glucose, wormy fruit and benzoate of soda are frequent admixtures and true meat is often omitted entirely. Wheat or rye flour is a common adulterant.

Examination of Mince Meat.—Meat and cereal flour may be identified by microscopic examination. Care should be taken not to confuse apple starch, which is always present in the immature fruit, with cereal starches. Meat fibers are recognized by their yellow brown color, the delicate transverse striations and their occurrence in bundles.

Determinations of nitrogen are of service in estimating the amount of meat present. Glucose and sugar are calculated from the polarization readings.

Pie Filling. Bakers and hotel cooks are supplied by manufacturers with filling prepared ready for use in pies. This material is shipped in pails or
tubs preserved with benzoate of soda, and may contain fruit of questionable quality as well as admixtures such as starch, glucose, and artificial colors.

**Maraschino Cherries.**—This name has been applied indiscriminately to the vivid red preserved cherries used in cocktails, punches, ice cream and confectionery. Investigation by the Board of Food and Drug Inspection has led to the decision * that only marasca cherries, preserved in true maraschino cordial prepared by fermentation and distillation from marasca cherries, are entitled to the name maraschino cherries, although cherries of other types preserved in pure maraschino cordial may be labelled: "Cherries in Maraschino." Ordinary cherries preserved in syrup flavored with maraschino may be so labelled, but if the flavoring is oil of bitter almonds or benzaldehyde the product should be labelled as an imitation if the word maraschino is used.

Enormous quantities of white cherries of the Bigarreau or Royal Anne type, preserved in a mixture of sulphurous acid and brine, are brought into the United States from Europe and transformed into red "Maraschino cherries" or green "Crème de menthe cherries." After removal of the sulphurous acid and brine the cherries are put through a dye bath and then, being quite without taste, are flavored with oil of bitter almond or benzaldehyde, or else peppermint, and packed in syrup. Scarcely more than the cellular structure of the original cherry remains, the fruit juice with its sugars, acids, and true cherry flavor being replaced by the syrup with its sickening flavor and aroma. Even if flavored with true maraschino the metamorphoses through which the fruit passes leave it a sorry substitute for the natural cherry.

Woodman and Davis † have shown that true maraschino contains very little benzaldehyde and that cherries flavored with maraschino should not contain more than two or three times as many milligrams of benzaldehyde per 100 cc. as there are grams of alcohol in that volume, and those containing over 20 mg. of benzaldehyde but no alcohol are evidently entirely artificial.

Artificial colors, sulphurous acid and other preservatives are detected by the methods given in the chapters on colors and preservatives, benzaldehyde by the following method:

**Determination of Benzaldehyde in Maraschino Cherries.**—*Woodman and Davis Method.*†—Reagent.—Mix 3 cc. of glacial acetic acid with

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* Food Inspection Decision 141.
40 cc. of water, add 2 cc. of C.P. phenyl hydrazine, as near colorless as possible, shake thoroughly, and filter the emulsion through several thicknesses of filter-paper. The clear filtrate should be used immediately as a turbidity appears on standing longer than five minutes.

Process.—Dilute 100 cc. of the liquor from maraschino cherries (or 50 cc. of maraschino liqueur) to 140 cc. and distill off 110 cc. Determine approximately the alcohol in the distillate by the pycnometer or immersion refractometer, then without delay transfer 100 cc. to a 300 cc. Erlenmeyer flask and add alcohol or water so that the solution shall contain approximately 10% of alcohol. Add 10 cc. of the reagent, stopper tightly with a rubber stopper, and shake vigorously for ten minutes. Collect the precipitate in a tared Gooch crucible, wash with cold water and finally with about 10 cc. of 10% alcohol. Dry in a vacuum desiccator for 20–24 hours at about 20 cm. pressure, or in a vacuum oven at 70–80° C. for 3 hours. Throughout the process avoid exposure of the precipitate to strong light.

Run a blank determination at the same time and deduct the weight obtained from that found in the actual analysis. Multiply the corrected weight of the precipitate by 0.5411, thus obtaining the weight of benzaldehyde.

JAMS AND JELLIES.

Jams or marmalades are prepared from the pulp of fruits, and jellies from the fruit juices. Both jams and jellies, to be considered of the highest degree of purity, should contain nothing but the fruit pulp or juice named on the label, mixed with pure cane sugar, and, in the case of jams, the further addition of spices and flavoring materials is permissible.

For the manufacture of jam, apples, quinces, and pears are peeled, freed from cores, and sliced; berries are simply stemmed; and stone fruits, such as peaches and apricots, are peeled, and freed from stones. The material, properly prepared, is cooked with as much water as is necessary for boiling, and with the addition of an amount of sugar varying with different manufacturers. Some prefer to use equal parts of sugar and fruit, others one part sugar to two parts fruit.

In the case of jelly, the fruit is cooked in a small amount of water till soft, transferred to a bag or press, and the juice allowed to flow out spontaneously, or is squeezed out under pressure, according to the grade of jelly desired, the clearest and finest varieties being made from the juice that flows out naturally. This juice is then evaporated down with the addition of sugar to a density of from 30° to 32° Bé., which is of the
proper consistency to form a perfect jelly product after cooling, and, while still hot, is poured into the tumblers in which it is to be kept. Here, as in the case of jams, the amount of sugar varies, some using pound for pound, and others only half as much sugar as fruit. Some manufacturers clarify their jellies by mixing with the juice, while boiling, elutriated chalk, using a teaspoonful to each quart of juice. The impurities come to the surface with the chalk as a scum, and are skimmed off. This clarifying process is somewhat analogous to the defecation of sugar juices with lime, and is commonly carried out with apple jelly.

The "jellying" or gelatinizing of the final product is due to the presence in the fruit juice of pectin, or so-called vegetable jelly (C_{32}H_{40}O_{264}H_{2}O), formed by the hydrolysis of pectose.

The high content of added sugar in jelly, once thought to be essential for keeping it, is now no longer considered necessary, and much less sugar is at present added than formerly. The finest grade of apple jelly, for instance, is made without any added sugar whatever.

In making the better grades of apple jelly, apple juice fresh from the press is run directly into the boiler or evaporator before any fermentation has ensued, and gelatinized by concentration. If boiled cider is wanted instead of jelly, it is drawn off at an earlier stage than in the case of apple jelly.

**Composition of Known-purity Jellies and Jams.**—In the tables on pages 992 and 993, due to Tolman, Munson, and Bigelow,* are given results reached in the examination of the pure finished products, as well as of pure fruit juices and pulp used in their manufacture.

**Imitation Jams and Jellies.**—Only a small percentage of the products sold in the United States belong in the same class with home-made jams and jellies consisting exclusively of the fruits in mixture with cane sugar. The cheap substitutes are made up largely of apple juice and commercial glucose, sometimes containing no fruit whatever of the kind specified on the label. Sometimes an attempt is made to imitate the flavor by the addition of artificial fruit essences, but more often the same apple-glucose stock mixture of jelly, put out under a particular brand, serves to masquerade as damson, strawberry, raspberry, currant, grape, etc., differing from each other only in color, but not as a rule in flavor. A variety of artificial colors are employed, mostly coal-tar dyes. To compensate for the lack of sweetness of the glucose, a minute quantity of one of the concentrated

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sweeteners, such as saccharin or dulcin, is sometimes added. Besides artificial colors, antiseptic substances are occasionally used, especially sodium benzoate.

All grades of apple stock are found in these preparations. A large source of supply is furnished by the parings and cores of canning establishments, to say nothing of the refuse of these factories, such materials being boiled with water, and the extract, variously colored to imitate the different fruits, being evaporated with commercial glucose.

Imitation Jellies.—While it is easy to make an excellent apple jelly by simple evaporation of the pure apple juice, even without the addition of sugar, it is impossible, or at least difficult, to obtain the proper degree of stiffness with a mixture of apple stock and commercial glucose. It is customary, in the manufacture of cheap jellies, therefore, to employ what is technically termed a “coagulator.” Formerly sulphuric acid, sometimes with addition of alum was used, but at present phosphoric acid is preferred. Citric or tartaric acid is also used for this purpose, as well as to increase the acidity. Less than 1% of acid will cause the mass to gelatinize satisfactorily.

The lowest grade of apple jelly is made from the exhausted pomace, left as a residue after pressing out the juice for cider. Such stock is commonly mixed with water, and boiled down with glucose. Having been exhausted of its malic acid, pectose, and other soluble constituents, it lacks much of the flavor inherent in pure apple jelly. Various foreign gelatinizing agents are found in cheap jellies and preserves, such as starch, gelatin, and agar-agar. In the low-priced goods, starch paste has been employed. It should be remembered that starch exists in unripe apples, but hardly at all in the mature fruit, so that while mere traces of starch in jelly may be due to the use of green apples, its presence in large amounts is undoubted evidence of the admixture of starch paste.

Imitation Jams.—Most of the cheap jams and bottled preserves sold on the market, though reinforced with apple stock, do in reality contain masses of fruit and berries of the kind stipulated on the label, as even a casual meagascopic examination will show. That such low-priced preparations really contain genuine fruit pulp is not to be wondered at, when it is considered that much of the virtue of this fruit has sometimes been previously extracted by boiling, to produce fruit juices for higher-priced goods. Or, as in the case of jams containing strawberries, raspberries, and other small fruits with seeds, the juice is apt to have been previously expressed for pure jellies, while the residues are afterwards
<table>
<thead>
<tr>
<th>Description of Sample</th>
<th>Total Solids, Per Cent.</th>
<th>Ash, Per Cent.</th>
<th>Total Acids Calculated as H₂SO₄, Per Cent.</th>
<th>Proteins (NX 0.25), Per Cent.</th>
<th>Sugars</th>
<th>Polarization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reducing Sugar, Per Cent.</td>
<td>Cane Sugar Added, Per Cent.</td>
</tr>
<tr>
<td>Apple (fall pippin)</td>
<td>7.95</td>
<td>0.47</td>
<td>0.627</td>
<td>0.543</td>
<td>4.00</td>
<td>1.18</td>
</tr>
<tr>
<td>Blackberry</td>
<td>8.54</td>
<td>0.52</td>
<td>0.978</td>
<td>0.350</td>
<td>4.34</td>
<td>0.00</td>
</tr>
<tr>
<td>Crab apple</td>
<td>5.62</td>
<td>0.20</td>
<td>0.372</td>
<td>0.075</td>
<td>2.56</td>
<td>1.03</td>
</tr>
<tr>
<td>Grape (fox)</td>
<td>6.67</td>
<td>0.49</td>
<td>1.086</td>
<td></td>
<td>2.79</td>
<td>0.37</td>
</tr>
<tr>
<td>Grape (Ives seedling)</td>
<td>8.85</td>
<td>0.57</td>
<td>0.902</td>
<td>0.237</td>
<td>5.10</td>
<td>0.89</td>
</tr>
<tr>
<td>Huckleberry</td>
<td>16.33</td>
<td>0.40</td>
<td>0.454</td>
<td>11.21</td>
<td>3.90</td>
<td>3.90</td>
</tr>
<tr>
<td>Orange (Florida navel)</td>
<td>6.08</td>
<td>0.36</td>
<td>0.297</td>
<td>0.581</td>
<td>1.52</td>
<td>2.29</td>
</tr>
<tr>
<td>Peach</td>
<td>8.90</td>
<td>0.45</td>
<td>0.218</td>
<td></td>
<td>4.59</td>
<td>4.59</td>
</tr>
<tr>
<td>Pear (Bartlett)</td>
<td>11.65</td>
<td>0.45</td>
<td>0.345</td>
<td>0.87</td>
<td>5.87</td>
<td>1.18</td>
</tr>
<tr>
<td>Pineapple</td>
<td>13.27</td>
<td>0.45</td>
<td>0.308</td>
<td>0.286</td>
<td>2.04</td>
<td>8.06</td>
</tr>
<tr>
<td>Pineapple-husk juice</td>
<td>8.43</td>
<td>0.77</td>
<td>0.150</td>
<td></td>
<td>4.73</td>
<td>4.73</td>
</tr>
<tr>
<td>Plum (Damson)</td>
<td>12.72</td>
<td>0.63</td>
<td>0.431</td>
<td></td>
<td>4.86</td>
<td>0.51</td>
</tr>
<tr>
<td>Plum (wild fox)</td>
<td>11.21</td>
<td>0.61</td>
<td>1.576</td>
<td>0.137</td>
<td>2.87</td>
<td>2.81</td>
</tr>
<tr>
<td>Mixed fruit</td>
<td>6.55</td>
<td>0.32</td>
<td>0.612</td>
<td>0.150</td>
<td>2.68</td>
<td>0.59</td>
</tr>
</tbody>
</table>

**Table II.**—JELLY.

<table>
<thead>
<tr>
<th>Description of Sample</th>
<th>Total Solids, Per Cent.</th>
<th>Ash, Per Cent.</th>
<th>Total Acids Calculated as H₂SO₄, Per Cent.</th>
<th>Proteins (NX 0.25), Per Cent.</th>
<th>Sugars</th>
<th>Polarization</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Reducing Sugar, Per Cent.</td>
<td>Cane Sugar Added, Per Cent.</td>
</tr>
<tr>
<td>Apple (fall pippin)</td>
<td>59.18</td>
<td>0.22</td>
<td>0.279</td>
<td>0.175</td>
<td>20.78</td>
<td>51.76</td>
</tr>
<tr>
<td>Blackberry</td>
<td>59.03</td>
<td>0.33</td>
<td>0.475</td>
<td>0.243</td>
<td>12.51</td>
<td>54.59</td>
</tr>
<tr>
<td>Crab apple</td>
<td>63.28</td>
<td>0.11</td>
<td>0.171</td>
<td>0.137</td>
<td>34.93</td>
<td>57.91</td>
</tr>
<tr>
<td>Grape (Ives seedling)</td>
<td>63.56</td>
<td>0.45</td>
<td>0.254</td>
<td>0.175</td>
<td>37.29</td>
<td>60.29</td>
</tr>
<tr>
<td>Huckleberry</td>
<td>63.62</td>
<td>0.28</td>
<td>0.245</td>
<td>0.008</td>
<td>24.27</td>
<td>39.19</td>
</tr>
<tr>
<td>Orange (Florida navel)</td>
<td>68.56</td>
<td>0.30</td>
<td>0.171</td>
<td>0.418</td>
<td>3.05</td>
<td>65.59</td>
</tr>
<tr>
<td>Peach</td>
<td>69.98</td>
<td>0.21</td>
<td>0.245</td>
<td>0.175</td>
<td>8.75</td>
<td>63.70</td>
</tr>
<tr>
<td>Pear (Bartlett)</td>
<td>69.12</td>
<td>0.34</td>
<td>0.181</td>
<td>0.116</td>
<td>6.58</td>
<td>63.09</td>
</tr>
<tr>
<td>Pineapple</td>
<td>80.28</td>
<td>0.43</td>
<td>0.328</td>
<td>0.357</td>
<td>22.13</td>
<td>72.68</td>
</tr>
<tr>
<td>Pineapple-husk juice</td>
<td>76.34</td>
<td>0.73</td>
<td>0.352</td>
<td>0.350</td>
<td>7.40</td>
<td>70.22</td>
</tr>
<tr>
<td>Plum (Damson)</td>
<td>45.56</td>
<td>0.68</td>
<td>1.127</td>
<td>0.350</td>
<td>10.18</td>
<td>38.00</td>
</tr>
<tr>
<td>Plum (wild fox)</td>
<td>54.40</td>
<td>0.40</td>
<td>0.706</td>
<td>0.13</td>
<td>24.00</td>
<td>48.05</td>
</tr>
<tr>
<td>Plum (wild fox) boiled down.</td>
<td>73.01</td>
<td>0.05</td>
<td>1.539</td>
<td>0.175</td>
<td>44.22</td>
<td>64.06</td>
</tr>
<tr>
<td>Mixed fruit</td>
<td>66.38</td>
<td>0.21</td>
<td>0.367</td>
<td>0.069</td>
<td>39.70</td>
<td>59.72</td>
</tr>
</tbody>
</table>

* The "juice" was prepared by cooking the fruit till soft, after the addition of sufficient water to prevent scorching, and straining through a jelly bag.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple (fall pippin)</td>
<td>0.30</td>
<td>8.25</td>
<td>0.490</td>
<td>4.13</td>
<td>1.03</td>
<td>-1.2</td>
<td>-3.6</td>
<td>-1.8</td>
<td>+0.8</td>
<td>-3.2</td>
<td>-3.2</td>
</tr>
<tr>
<td>Blackberry</td>
<td>0.75</td>
<td>1.75</td>
<td>0.96</td>
<td>0.75</td>
<td>1.70</td>
<td>-1.6</td>
<td>-3.0</td>
<td>-2.0</td>
<td>+0.8</td>
<td>-2.5</td>
<td>-2.5</td>
</tr>
<tr>
<td>Crab apple seedling</td>
<td>0.75</td>
<td>8.48</td>
<td>0.96</td>
<td>0.75</td>
<td>1.70</td>
<td>-1.6</td>
<td>-3.0</td>
<td>-2.0</td>
<td>+0.8</td>
<td>-2.5</td>
<td>-2.5</td>
</tr>
<tr>
<td>Orange (Florida navel)</td>
<td>0.68</td>
<td>15.11</td>
<td>0.96</td>
<td>0.686</td>
<td>3.33</td>
<td>-3.6</td>
<td>-7.0</td>
<td>-3.6</td>
<td>+3.6</td>
<td>-7.0</td>
<td>-7.0</td>
</tr>
<tr>
<td>Pineapple</td>
<td>0.68</td>
<td>8.81</td>
<td>0.96</td>
<td>0.686</td>
<td>3.33</td>
<td>-3.6</td>
<td>-7.0</td>
<td>-3.6</td>
<td>+3.6</td>
<td>-7.0</td>
<td>-7.0</td>
</tr>
</tbody>
</table>

*The composition here given is not that of the original fruit, but of the product made in the preparation of jam.*
worked up with apple stock for low-priced jams. Hence the presence of pure fruit stock, or genuine berry seeds and pulp in jams, is in itself no criterion of purity, and furthermore, it is unnecessary to use hay seed and other alleged foreign seeds as adulterants of cheap jam.

**Compound Goods.**—Many states have a law legalizing the sale of "compound" goods, providing they are distinctly so labeled. In other states, as, for instance, Massachusetts, the label must plainly state the name and percentage of the ingredients. In either case the analyst must discriminate, in classifying the inferior or low-grade preparations, between those that are labeled in accordance with the law, and those that are not. Only those not properly labeled can in such cases be classed as adulterated within the meaning of the law. Where such a law prevails, probably no class of food-products is so extensively affected by it as the low-grade jams, preserves, and jellies.

The restrictions as to labeling do not in all cases eliminate the element of deception. It is hardly justifiable, for example, to boldly label an alleged "currant jelly" which contains no currant, in the following manner:

<table>
<thead>
<tr>
<th>Fruit juice</th>
<th>25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cane sugar</td>
<td>14%</td>
</tr>
<tr>
<td>Corn syrup</td>
<td>61%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The use of the term "fruit juice" surely implies to the unsuspecting purchaser that so much pure currant juice has entered into the jelly, elsewhere labeled in large letters "Currant," whereas all the juice is apple, and no currant juice has been used.

The following label is a type of those which discriminate between pure fruit and apple juice:

<table>
<thead>
<tr>
<th>Fruit</th>
<th>30%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn syrup</td>
<td>35%</td>
</tr>
<tr>
<td>Granulated sugar</td>
<td>15%</td>
</tr>
<tr>
<td>Apple juice</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**Composition of Cheaper Grades.**—Out of 66 samples of jellies, jams, and preserves analyzed by Winton, Langley, and Ogden in Connecticut, the samples being purchased in that state,* 17 samples contained starch

<table>
<thead>
<tr>
<th>Description of Sample</th>
<th>Ash (in ppm)</th>
<th>Total Sugar (Polarization)</th>
<th>Sugar from Pure Cane (Per Cent.)</th>
<th>Added Sugar (Per Cent.)</th>
<th>Dry Extract at 100° C.</th>
<th>Extract at 100° C.</th>
<th>Sugar from Pure Cane (Per Cent.)</th>
<th>Added Sugar (Per Cent.)</th>
<th>Dry Extract at 100° C.</th>
<th>Extract at 100° C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple (fall pippins)</td>
<td>8.25</td>
<td>0.29</td>
<td>0.71</td>
<td>0.68</td>
<td>4.13</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
<tr>
<td>Blackberry</td>
<td>9.62</td>
<td>0.60</td>
<td>0.71</td>
<td>0.85</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
<tr>
<td>Crab apple (seedling)</td>
<td>11.89</td>
<td>0.61</td>
<td>0.71</td>
<td>0.95</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
<tr>
<td>Orange (Florida navel)</td>
<td>13.11</td>
<td>0.61</td>
<td>0.71</td>
<td>0.85</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
<tr>
<td>Pineapple</td>
<td>13.47</td>
<td>0.61</td>
<td>0.71</td>
<td>0.85</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
</tbody>
</table>

*The composition here given is not that of the original fruit, but of the product made in the preparation of jam.*

Table IV.—JAM.

<table>
<thead>
<tr>
<th>Description of Sample</th>
<th>Ash (in ppm)</th>
<th>Total Sugar (Polarization)</th>
<th>Sugar from Pure Cane (Per Cent.)</th>
<th>Added Sugar (Per Cent.)</th>
<th>Dry Extract at 100° C.</th>
<th>Extract at 100° C.</th>
<th>Sugar from Pure Cane (Per Cent.)</th>
<th>Added Sugar (Per Cent.)</th>
<th>Dry Extract at 100° C.</th>
<th>Extract at 100° C.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple (fall pippins)</td>
<td>63.22</td>
<td>0.39</td>
<td>0.74</td>
<td>0.95</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
<tr>
<td>Blackberry</td>
<td>85.42</td>
<td>0.71</td>
<td>0.74</td>
<td>0.95</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
<tr>
<td>Crab apple (seedling)</td>
<td>86.64</td>
<td>0.48</td>
<td>0.74</td>
<td>0.85</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
<tr>
<td>Grape (Florada navel)</td>
<td>86.43</td>
<td>0.48</td>
<td>0.74</td>
<td>0.95</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
<tr>
<td>Peach (Bartlett)</td>
<td>64.72</td>
<td>0.26</td>
<td>0.74</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
<tr>
<td>Pineapple (wild one)</td>
<td>62.10</td>
<td>0.46</td>
<td>0.74</td>
<td>0.95</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
<td>3.93</td>
<td>1.03</td>
</tr>
</tbody>
</table>

*The composition here given is not that of the original fruit, but of the product made in the preparation of jam.*
**Determination of Total Solids.**—Weigh 4 to 5 grams of the sample into a large flat-bottomed dish (preferably of platinum) containing from 4 to 5 grams of ignited asbestos and add enough water to uniformly distribute the material. Evaporate to dryness and dry for from twenty to twenty-four hours in a boiling water-oven.

The results by this method are not strictly accurate owing to the dehydration of levulose, but for practical purposes they are sufficiently close. If extreme accuracy is required dry in vacuo at 70° or in a McGill oven (page 609).

The solids in a jelly may also be calculated from the specific gravity.

**Determination of Ash.**—Burn the residue from the determination of solids, or else a new portion, in a platinum dish at dull redness.

Alkalinity of ash is determined as described for insoluble ash in maple products (page 657).

Chlorides and Sulphates are detected in the ash by the usual tests. If the portion used for determination of alkalinity is also to be used for the chlorine test the titration must be made with fifth-normal nitric acid.

The presence of chlorides is an indication of glucose, as pure fruit products do not contain appreciable amounts of chlorine compounds.

**Determination of Insoluble Solids.**—Kremla Method.*—Thoroughly macerate 50 grams of the sample in a mortar with warm water, then transfer to a filter and wash thoroughly with warm water, stirring well after each addition. Wash up to 500 cc., or in extreme cases up to 1000 cc., remove the insoluble solids to a dish, dry in a boiling water-oven, and weigh. Kremla employed a coarse filter paper for collecting the insoluble solids; Munson and Tolman † found muslin more satisfactory.

Reserve the filtrate for determinations of soluble constituents.

**German Official Method.**‡—Transfer a weighed portion of the sample to a graduated flask, add water, shake thoroughly and make up to volume. Allow to settle and either filter or decant off the supernatant liquid. Determine the soluble solids by evaporating and drying an aliquot. The insoluble solids are obtained by subtracting the soluble from the total solids.

**Determination of Acidity.**—Dilute an aliquot of the solution from the insoluble solids of a jam or of a solution of a jelly and titrate with standard alkali. Use phenolphthalein as indicator if the color of the

---

solution will permit, otherwise use litmus paper. Calculate the result as sulphuric acid or as the organic acid known to predominate (see page 1008).

Some of the methods for the determination of individual acids in fruit juices (pages 1008 and 1009) are applicable to jams and jellies, but the analyst will do well to test their accuracy on mixtures of known composition, especially if substances other than fruit and sugar are present.

**Determination of Protein.**—Determine nitrogen in 5 grams of the material by the Kjeldahl or Gunning method and calculate protein, using the factor 6.25.

**Determination of Sugars.**—In products of the highest grade, wherein only cane sugar is employed, a large portion of the cane sugar is inverted in the process of boiling the jam or jelly, so that when the analyst examines it, he finds, as a rule, only a small amount of sucrose, and considerable invert sugar. The amount of cane sugar equivalent to the invert sugar may be calculated if this is thought desirable. It is further of interest to calculate, at least approximately, the percentage of commercial glucose, when present, especially in cases where the package contains a formula setting forth the amount of the various ingredients used. In such cases the analyst is naturally called upon to verify the formula, since a wide variation in percentage composition from the statement on the label would constitute an offense under same state laws.

**Polarization.**—Use half the normal weight of the preserve or jelly for the Schmidt and Haensch instrument, namely 13 grams in 100 cc. If fresh fruit or fruit juice is to be examined, use the full normal weight, 26 grams. Clarify, before making up to the mark, with subacetate of lead and alumina cream (using 2 to 3 cc. of each clarifier), filter, and obtain the direct reading; then invert in the usual manner, and obtain the invert readings at 20° C., and in the water-jacketed tube at 85° C., proceeding in detail as directed under honey, page 671.

**Calculation of Sugars.**—**Sucrose** is determined by using the Clerget-Herzfeld formula:

$$S = \frac{(a - b) \times 100}{142.66 - \frac{1}{2}}$$

This represents the sucrose actually present as such in the preserve or jelly, and not the amount originally used. If the latter ($S'$) is desired, it may be roughly calculated by the following formula:
\[ S' = \frac{100b}{42.66 - \frac{t}{2}} \] (2)

The results by this formula are too high, since part of the invert sugar was a natural constituent of the fruit.

If, after inversion, the correct reading at 20° is found to be 12 or more to the left of the zero, it can be safely inferred that no appreciable amount of commercial glucose is present, and it is unnecessary to make a third reading at 87°, unless to confirm the fact. In such a case, with cane sugar alone present, the reading at 87° will not, of course, vary much from zero.

**Invert Sugar.**—In the absence of commercial glucose, the invert sugar is calculated as follows:

\[ \text{Invert sugar} = \frac{(\text{Sucrose} - \text{direct reading})}{42.66 - \frac{t}{2}} \times 105.3 \] (3)

or it may be determined directly from the copper reducing power.

Any decided reading above zero at 87° is due to the presence of commercial glucose, and when the latter is present, it is impossible to determine the invert sugar from the copper reduction or by formula No. 3. The following formula is proposed for calculating approximately the invert sugar from the polarization, in the presence of commercial glucose. While theoretically correct, the method is subject to practical limitations, which admit of only roughly approximate results in such mixtures as jelly or jam. It is perfectly accurate only in mixtures of sucrose, glucose, and invert sugar.

\[ \text{Invert sugar} = \frac{\left( \text{Reading due to glucose and inverted sucrose at } t^\circ \right) - \left( \text{Invert reading at } t^\circ \right)}{\pm \left( 42.66 - \frac{t}{2} \right)} \times 105.3 \] (4)

These formulas, (3) and (4), serve at best to indicate the approximate amount of invert sugar present in the sample, resulting from the inversion of a portion of the original sucrose in the natural process of manufacture of the jam or jelly, and not the total invert sugar resulting from the inversion by the analyst of all the sucrose.

The factor 105.3 is used, since, in the natural process of inversion, 100 parts of sucrose become 105.3 parts of invert sugar.

**Example.**—The invert sugar in the sample of apple jelly first on the list in the table on page 995 is calculated as follows:
Invert reading at $f^0$ (20°) = 28.0.
Reading due to glucose at 20° = 0.221 \times 1.75 = 38.68.
Reading due to inverted sucrose at 20° = 0.268 \times -34 = -9.11.
Invert sugar = \frac{(38.68 - 9.11) - 28}{28.66} = 105.3
= 5.76%.

**Determination of Reducing Sugar.**—Proceed as described on page 98a.

**Commercial Glucose.**—While it is impossible to determine the exact percentage of this substance in preserves and jellies, by reason of the varying composition of its component parts, it is quite feasible to approximate very closely to the amount present. Indeed, this approximate method of calculation, wherein glucose is treated as a chemical entity, has been found in practice to be much more close to the actual truth than results gained by methods wherein the copper-reducing power enters as a factor, or methods for determining separately dextrin, maltose, and dextrose. Calculate the commercial glucose in jellies and jams exactly as in the case of honey, page 673.

**Detection of Dextrin.**—Add alcohol to a somewhat thick solution of the fruit product. A white turbidity is at once apparent, followed by the formation of a thick gummy precipitate if dextrin is present. In the absence of dextrin there is no turbidity, but a light flocculent precipitate.

**Determination of Dextrin.**—**Bigelow and McElroy Method.**—Dissolve 10 grams of the sample in a 100-cc. graduated flask, add 20 mg. of potassium fluoride, and then about one-quarter of a cake of compressed yeast. Allow the fermentation to proceed below 25° C. for two or three hours to prevent excessive foaming, and then place in an incubator at a temperature of from 27° to 30° C. for five days. At the end of that time clarify with lead subacetate and alumina cream; make up to 100 cc. and polarize in a 200-mm. tube. A pure fruit jelly will show a rotation of not more than a few tenths of a degree either to the right or to the left. If a Schmidt and Haensch polarscope be used, and a 10% solution be polarized in a 200-mm. tube, the number of degrees read on the sugar scale of the instrument, multiplied by 0.8755, will give the percentage of dextrin, or the following formula may be used:

\[
\text{Percentage of dextrin} = \frac{C \times 1000 \times V}{198 \times L \times W}
\]

in which

\[ C = \text{degrees of circular rotation}; \]
\[ V = \text{volume in cubic centimeters of solution polarized}; \]
\[ L = \text{length of tube in centimeters}; \]
\[ W = \text{weight of sample in solution in grams}. \]

**Determination of Crude Pectin (Alcohol Precipitate).**—*Munson and Tolman Method.*—Evaporate 100 cc. of a 20\% solution of jelly, or 200 cc. of the washings from the determination of insoluble solids of a jam, to 20 cc.; add slowly and with constant stirring 200 cc. of 95\% alcohol and allow the mixture to stand overnight. Filter and wash with 80\% alcohol by volume. Wash this precipitate off the filter paper with hot water into a platinum dish; evaporate to dryness; dry at 100° C. for several hours and weigh; then burn off the organic matter and weigh the residue as ash. The loss in weight upon ignition is called alcohol precipitate.

The ash should be largely lime and not more than 5\% of the total weight of the alcohol precipitate. If it is larger than this some of the salts of the organic acids have been brought down. Titratre the water-soluble portion of this ash with tenth-normal acid, as any potassium bitartrate precipitated by the alcohol can thus be estimated.

The general appearance of the alcohol precipitate is one of the best indications as to the presence of glucose and dextrin. Upon the addition of alcohol to a pure fruit product a flocculent precipitate is formed with no turbidity while in the presence of glucose a white turbidity appears at once upon adding the alcohol, and a thick, gummy precipitate forms. Since the precipitate in the latter case consists in part of substances other than pectin bodies the results should be stated as representing "alcohol precipitate" and not "pectin."

**German Method.**†—This method, designed for juices, may also be used for jams and jellies. It differs from the Munson and Tolman method chiefly in that a smaller proportion of alcohol is used and a correction is introduced for protein.

**Detection of Coloring Matter.**—Boil white woolen cloth or worsted in a solution of the jelly or jam, acidified with hydrochloric acid, or with acid sulphate of potassium, according to Arata's method and test for

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the color on the dyed fabric by methods given in detail in Chapter XVII. Apply also the general methods described in that chapter.

**Detection of Preservatives and Concentrated Sweeteners.**—Extract an acid aqueous solution of the fruit product with ether or chloroform in a separatory funnel, and test for benzoic and salicylic acids and for saccharin in the ether extract. If dulcin is suspected, extract with acetic ether.

**Detection of Starch.**—Heat an aqueous solution of the preserve or jelly nearly to the boiling point, and decolorize by the addition of several cubic centimeters of dilute sulphuric acid and afterwards permanganate of potassium. This treatment does not affect the starch, which is tested for with iodine in the ordinary manner in the solution after cooling. In the clear filtrate from a boiled apple pulp solution, free from added starch, little or no darkening should occur on the addition of the iodine reagent. If, however, the reagent is added to the residue of the previously boiled pulp, the presence of starch inherent in the apple is usually recognized by the blue color produced thereon.

The presence of any considerable added starch paste in a fruit preparation is thus readily indicated by an intense blue color obtained by adding the iodine reagent to the filtrate (free from fruit pulp).

**Detection of Gelatin.**—*Robin's Method.*†—Add to a thick aqueous solution of the preserve or jelly sufficient strong alcohol to precipitate the gelatin. Decant the supernatant liquid after settling, set aside part of the precipitate, and dissolve the remainder in water. Divide the latter solution in two parts, to one of which add, drop by drop, a fresh solution of tannin, which precipitates gelatin if present. To the remainder add picric acid solution, which in presence of gelatin forms a yellow precipitate. The portion of the yellow precipitate set aside is transferred to a test tube, and heated over the flame with a little quicklime. If gelatin is present, ammonia will be given off, apparent by the odor, and by fumes of ammonium chloride when a drop of hydrochloric acid on a glass rod is held at the mouth of the bottle.

**Leffmann and Beam's Method.**‡—Boil the sample with water, filter, and boil the filtrate with an excess of potassium bichromate. Cool, and add a few drops of sulphuric acid. A flocculent precipitate indicates gelatin.

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† Girard, Analyse des Matières Alimentaires, p. 676.
‡ Select Methods of Food Analysis, p. 324.
in which

\[ C = \text{degrees of circular rotation}; \]
\[ V = \text{volume in cubic centimeters of solution polarized}; \]
\[ L = \text{length of tube in centimeters}; \]
\[ W = \text{weight of sample in solution in grams}. \]

**Determination of Crude Pectin (Alcohol Precipitate).**—*Munson and Tolman Method.*—Evaporate 100 cc. of a 20% solution of jelly, or 200 cc. of the washings from the determination of insoluble solids of a jam, to 20 cc.; add slowly and with constant stirring 200 cc. of 95% alcohol and allow the mixture to stand overnight. Filter and wash with 80% alcohol by volume. Wash this precipitate off the filter paper with hot water into a platinum dish; evaporate to dryness; dry at 100° C. for several hours and weigh; then burn off the organic matter and weigh the residue as ash. The loss in weight upon ignition is called alcohol precipitate.

The ash should be largely lime and not more than 5% of the total weight of the alcohol precipitate. If it is larger than this some of the salts of the organic acids have been brought down. Titrate the water-soluble portion of this ash with tenth-normal acid, as any potassium bitartrate precipitated by the alcohol can thus be estimated.

The general appearance of the alcohol precipitate is one of the best indications as to the presence of glucose and dextrin. Upon the addition of alcohol to a pure fruit product a flocculent precipitate is formed with no turbidity while in the presence of glucose a white turbidity appears at once upon adding the alcohol, and a thick, gummy precipitate forms. Since the precipitate in the latter case consists in part of substances other than pectin bodies the results should be stated as representing "alcohol precipitate" and not "pectin."

**German Method.**—This method, designed for juices, may also be used for jams and jellies. It differs from the Munson and Tolman method chiefly in that a smaller proportion of alcohol is used and a correction is introduced for protein.

**Detection of Coloring Matter.**—Boil white woolen cloth or worsted in a solution of the jelly or jam, acidified with hydrochloric acid, or with acid sulphate of potassium, according to Arata’s method and test for

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to the minimum. From the sanitary standpoint dried fruit has certain advantages, notably the freedom from metallic impurities from the containers; on the other hand, great care is required to protect the material during drying and handling from surface contamination.

Xanti currants as well as raisins are dried grapes of certain European varieties. These, together with figs and dates, although produced in California and the Southern States, are imported into the United States in enormous quantities from the regions adjoining the Mediterranean. Apples, prunes, apricots, peaches, and cherries, on the other hand, are produced in the United States in quantities not only sufficient for domestic needs but also for export.

California fruits, such as raisins, prunes, apricots, peaches, and pears are sun-dried, as are also raisins, figs, dates and other fruits produced about the Mediterranean. Apples are commonly dried in the United States by artificial heat, although the old process of sun drying is still practiced on a small scale in certain regions.

Treatment with Lye.—Preliminary to drying certain fruits, such as raisins and prunes, are often dipped in a hot but weak solution of potash, which removes the bloom and otherwise acts on the skin, thus facilitating drying. Oil is also used with the lye in preparing "oil-dipped" Smyrna raisins. These methods of treatment are quite distinct from the lye-peeling process employed in preparing peaches, apricots, and some other fruits for canning.

Sulphuring of Fruit.—The treatment of fruits with the fumes of burning sulphur is practiced not only to bleach and prevent discoloration, but also to ward off the attacks of insects, fungi, and bacteria. It is allowed with restrictions in most European countries and also, pending further investigation, in the United States, provided the amount of sulphur dioxide remaining in the fruit does not exceed 350 mg. per kilo, of which not more than 70 mg. is free sulphurous acid.*

There is reason to believe that the sulphur dioxide exists in dried fruits in combination largely, if not wholly, with sugar, although possibly to some extent, as in wines, with acetaldehyde, or even with protein and cellulose.

Sulphuring when used for purposes of deception, as for example in rejuvenating old or damaged stock or when used in excessive amount, is obviously improper. Analyses by government chemists show that when

* U. S. Dept. of Agric., Off. of Sec., Food Inspection Decision 76.
no restrictions were placed on sulphuring as high as 3072 mg. per kilo were present in dried peaches, 2842 mg. in California apricots and 1738 mg. in evaporated apples.

**Moisture Content of Dried Fruits.**—An excessive amount of moisture in dried fruit is not only a worthless make-weight, but also facilitates the growth of molds and bacteria, causing rapid deterioration. In 1904 a law was passed in New York State requiring that dried apples contain not above 27% of moisture, determined by drying four hours at the temperature of boiling water.

**Wormy and Decomposed Dried Fruits.**—Figs, dates, and currants from Europe, also dried apples, cherries, and other fruits of domestic production often arc infected with worms or arc in a moldy or fermented condition due to careless drying or packing. Under the federal law such "filthy, decomposed or putrid " fruit is adulterated.

**Zinc in Dried Fruit.**—Apples dried in contact with galvanized iron trays may contain 0.01 to 0.02%, or in extreme cases, according to Loock, 0.09% of zinc as malate. This contamination may be avoided by greasing the trays, covering them with greased cloths, or using wooden trays.

**FRUIT JUICES.**

Such preparations, if of the highest purity, should consist of the undiluted juices of these fruits, separated by pressure and carefully sterilized and bottled. They should contain no other fruit juice than that specified on their labels, and should be free from alcohol, added antiseptics, or coloring matter, unless the label specifies the presence of the added foreign materials. The addition of pure cane sugar to such preparations as grape juice is allowable if declared, as well as charging with carbon dioxide to form so-called carbonated drinks.

**Composition of Fruit Juices.**—Analyses of various fruit juices, pressed out in the laboratory, by Munson and Tolman are given on page 992.

The following analyses of pure fruit juices are taken from tables prepared by Winton, Ogden, and Mitchell, showing results on samples purchased in the Connecticut market, as well as on some samples made in the laboratory.*

### VEGETABLE AND FRUIT PRODUCTS.

**COMMERCIAL FRUIT JUICES.**

<table>
<thead>
<tr>
<th>Solids.</th>
<th>Acids Other than CO₂</th>
<th>Cane Sugar</th>
<th>Invert Sugar</th>
<th>Polarization</th>
<th>After Inversion</th>
<th>Temperature °C</th>
<th>Invert Reading at 80° C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Direct</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blackberry</td>
<td>5.33</td>
<td>0.65</td>
<td>0.0</td>
<td>4.6</td>
<td>-1.3</td>
<td>-1.3</td>
<td>26.0</td>
</tr>
<tr>
<td>Cherry</td>
<td>14.33</td>
<td>0.80</td>
<td>0.0</td>
<td>6.5</td>
<td>-1.0</td>
<td>-1.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Black currant</td>
<td>10.00</td>
<td>2.41</td>
<td>0.0</td>
<td>9.2</td>
<td>-2.7</td>
<td>-2.7</td>
<td>26.0</td>
</tr>
<tr>
<td>Red currant</td>
<td>7.58</td>
<td>2.00</td>
<td>0.0</td>
<td>7.2</td>
<td>-2.1</td>
<td>-2.1</td>
<td>27.0</td>
</tr>
<tr>
<td>Grape</td>
<td>14.30</td>
<td>0.92</td>
<td>0.0</td>
<td>7.0</td>
<td>-0.5</td>
<td>-0.5</td>
<td>25.0</td>
</tr>
<tr>
<td>Lime fruit</td>
<td>7.78</td>
<td>6.50</td>
<td>0.0</td>
<td>0.0</td>
<td>-1.0</td>
<td>-1.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Orange</td>
<td>12.72</td>
<td>2.44</td>
<td>0.0</td>
<td>7.1</td>
<td>-2.1</td>
<td>-2.1</td>
<td>26.0</td>
</tr>
<tr>
<td>Pineapple</td>
<td>8.07</td>
<td>0.81</td>
<td>1.5</td>
<td>5.1</td>
<td>0.0</td>
<td>-2.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Plum</td>
<td>10.81</td>
<td>1.00</td>
<td>0.0</td>
<td>0.3</td>
<td>-0.1</td>
<td>-0.1</td>
<td>26.0</td>
</tr>
<tr>
<td>Quince</td>
<td>10.47</td>
<td>0.09</td>
<td>0.0</td>
<td>5.0</td>
<td>-5.0</td>
<td>-5.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Black raspberry</td>
<td>8.47</td>
<td>1.36</td>
<td>0.0</td>
<td>7.8</td>
<td>-2.3</td>
<td>-2.3</td>
<td>26.0</td>
</tr>
<tr>
<td>Strawberry</td>
<td>5.69</td>
<td>0.99</td>
<td>0.0</td>
<td>5.1</td>
<td>-1.5</td>
<td>-1.5</td>
<td>26.0</td>
</tr>
</tbody>
</table>

**MADE IN LABORATORY.**

<table>
<thead>
<tr>
<th>Solids.</th>
<th>Acids Other than CO₂</th>
<th>Cane Sugar</th>
<th>Invert Sugar</th>
<th>Polarization</th>
<th>After Inversion</th>
<th>Temperature °C</th>
<th>Invert Reading at 80° C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peach</td>
<td>12.70</td>
<td>0.95</td>
<td>5.4</td>
<td>4.1</td>
<td>4.8</td>
<td>-2.2</td>
<td>28.0</td>
</tr>
<tr>
<td>Red raspberry</td>
<td>9.47</td>
<td>1.19</td>
<td>0.8</td>
<td>7.6</td>
<td>-1.6</td>
<td>-2.8</td>
<td>26.0</td>
</tr>
<tr>
<td>Blackberry</td>
<td>8.04</td>
<td>1.22</td>
<td>0.0</td>
<td>8.7</td>
<td>-3.4</td>
<td>-2.4</td>
<td>30.0</td>
</tr>
<tr>
<td>Huckleberry</td>
<td>11.40</td>
<td>0.31</td>
<td>0.6</td>
<td>7.8</td>
<td>-4.0</td>
<td>-4.8</td>
<td>30.0</td>
</tr>
<tr>
<td>Pineapple</td>
<td>13.90</td>
<td>0.68</td>
<td>7.4</td>
<td>9.1</td>
<td>4.7</td>
<td>-4.8</td>
<td>28.0</td>
</tr>
</tbody>
</table>

### Grape Juice.—Following are the averages of analyses of grape juice made from European varieties of grapes reported by Bioletti and dal Piaz.*

### Alcohol, Solids, Sugar, Acidity, Volatile Acid, Free Tartaric Acid, Cream of Tartar, Ash, Phosphoric Acid.

<table>
<thead>
<tr>
<th>Alcohol, Solids, Sugar, Acidity, Volatile Acid, Free Tartaric Acid, Cream of Tartar, Ash, Phosphoric Acid.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Made in—</td>
</tr>
<tr>
<td>Austria</td>
</tr>
<tr>
<td>California</td>
</tr>
</tbody>
</table>

The table given below, summarized from tables by Hartmann and Tolman,† shows the maximum, minimum, and average of analyses of 93 samples of commercial grape juice obtained under supervision at five factories in New York state and one in Ohio during the years 1912, 1913, and 1914.

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† U. S. Dept. of Agric., Bul. 656, 1918.
FOOD INSPECTION AND ANALYSIS.

| Alcohol Vol. per Cent.* | Solids† | Sugars Calc. as Invert. | Acidity Calc. as Tartaric § | Free and Combined Tartaric Acid ||| | Free Tartaric Acid ||| | Cream of Tartar | Ash | Tannin and Coloring Matter.** | Alkalinity Water-soluble Ash | Alkalinity Water-insoluble Ash |
|------------------------|--------|------------------------|----------------------------|--------------------------------|---------------------------------|----------------------------|--------------------------------|--------------------------------|----------------------------|-----------------|-----------------|------------------|------------------|
| Max.                   | 0.37   | 20.78                  | 17.53                      | 1.28                          | 1.01                           | 0.36                        | 0.70                          | 0.37                          | 0.37                        | 42.0            | 8.8             |
| Min.                   | 0.02   | 14.20                  | 11.52                      | 0.81                          | 0.56                           | 0.12                        | 0.36                          | 0.22                          | 0.07                        | 19.0            | 3.1             |
| Aver.                  | 0.12   | 18.33                  | 15.31                      | 1.01                          | 0.74                           | 0.23                        | 0.54                          | 0.29                          | 0.24                        | 28.7            | 5.1             |

*By immersion refractometer.
† Briaz.
‡ Direct and invert polarization practically the same.
§ Spotted into litmus solution.
|| Total tartaric acid by Hartmann and Eoff method (p. 731).
¶ Calc. from total tartaric acid and cream of tartar (p. 733).
** Lowenthal method.

**Sweet Cider.**—The composition of purer, freshly expressed apple juice is shown by the following table of analyses by Browne:*

<table>
<thead>
<tr>
<th></th>
<th>Specific Gravity</th>
<th>Solids</th>
<th>Invert Sugar</th>
<th>Sucrose</th>
<th>Total Sugar</th>
<th>Total Sugar after Inversion</th>
<th>Free Maleic Acid</th>
<th>Ash</th>
<th>Undetermined (Pectin, etc.)</th>
<th>Left-handed Rotation Degrees</th>
<th>Ventske 450 mm. Tube</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red astrachan</td>
<td>1.0532</td>
<td>12.78</td>
<td>6.87</td>
<td>3.63</td>
<td>10.50</td>
<td>10.69</td>
<td>0.37</td>
<td>0.77</td>
<td>23.72</td>
<td>24.39</td>
<td></td>
</tr>
<tr>
<td>Early harvest</td>
<td>1.0552</td>
<td>13.20</td>
<td>7.49</td>
<td>3.07</td>
<td>11.46</td>
<td>11.67</td>
<td>0.28</td>
<td>0.65</td>
<td>30.40</td>
<td>36.16</td>
<td></td>
</tr>
<tr>
<td>Yellow transparent</td>
<td>1.0502</td>
<td>11.71</td>
<td>8.03</td>
<td>2.10</td>
<td>10.14</td>
<td>10.24</td>
<td>0.86</td>
<td>0.44</td>
<td>36.40</td>
<td>32.87</td>
<td></td>
</tr>
<tr>
<td>Sweet bough</td>
<td>1.0498</td>
<td>11.87</td>
<td>7.61</td>
<td>3.08</td>
<td>10.69</td>
<td>10.85</td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baldwin, green</td>
<td>1.0488</td>
<td>11.30</td>
<td>6.96</td>
<td>1.63</td>
<td>8.59</td>
<td>8.68</td>
<td>1.24</td>
<td>0.31</td>
<td>1.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;&quot;</td>
<td>1.0736</td>
<td>16.82</td>
<td>7.07</td>
<td>7.05</td>
<td>15.02</td>
<td>15.39</td>
<td>0.67</td>
<td>0.26</td>
<td>0.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ben Davis</td>
<td>1.0539</td>
<td>12.77</td>
<td>7.11</td>
<td>3.85</td>
<td>10.90</td>
<td>11.16</td>
<td>0.46</td>
<td>0.28</td>
<td>1.07</td>
<td>49.00</td>
<td></td>
</tr>
</tbody>
</table>

Determination of sugars in the juice of 15 American and 5 French varieties of apples made by Eoff† showed that in every instance the amount of levulose exceeded that of dextrose and sucrose combined.

Bottled sweet cider, properly sterilized, should not differ materially from the fresh juice, and should contain no considerable amount of alcohol.
Salicylic acid, sodium benzoate and sodium or calcium bisulphite have been extensively used as preservatives. Benzoate is still used to some extent.

**Lime or Lemon Juice.**—The juice of both the lime and the lemon is known commercially as lime juice and the Canadian standard goes so far

* Penn. Dept. Agric., Bul. 58, p. 29.
as to recognize "various species" of *Citrus*. In former editions of the U. S. Pharmacopoeia *C. limonum* was specified and the product known as lemon juice was required to conform to the following: Specific gravity at 15° C. at least 1.030, citric acid about 7%, and ash not more than 0.5%. In the 9th decimal revision neither lemon nor lime juice is given.

The table below shows the range in composition of 40 samples classed by McGill * as genuine, together with the Canadian limits fixed by Order of Council, Jan. 28, 1915. Many of the samples were preserved with benzoic, salicylic, or sulphurous acid.

### COMPOSITION OF LIME JUICE (McGill)

<table>
<thead>
<tr>
<th></th>
<th>Specific Gravity, 20° C</th>
<th>Total Solids</th>
<th>Acidity Calc. as Citric</th>
<th>Rotation in 500-cc. Tube, ° V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genuine lime juice:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>1.0531</td>
<td>12.12</td>
<td>10.18</td>
<td>+0.6</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.0305</td>
<td>7.76</td>
<td>6.93</td>
<td>−2.2</td>
</tr>
<tr>
<td>Canadian limits:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>1.040</td>
<td>....</td>
<td>....</td>
<td>+0.5</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.030</td>
<td>8.00</td>
<td>7.00</td>
<td>−1.0</td>
</tr>
</tbody>
</table>

Samples examined in previous years at the laboratory of Inland Revenue, Canada, and at the Mass. State Board of Health were often found to be watered, preserved with salicylic, benzoic, or sulphurous acid, artificially colored, or otherwise sophisticated. One sample, examined by Leach purporting to be "pure West Indian lime juice, triple refined," proved to be a mixture of hydrochloric and salicylic acids, colored with a coal-tar dye, and containing no lime juice whatever.

### METHODS OF ANALYSIS.

**Total Solids, Total Nitrogen, Ash, and Sugars** are determined by the methods employed for jams and jellies (pp. 995 to 1002), **Solubility and Alkalinity of the Ash and Phosphoric Acid** as described in the chapter on vinegar (p. 795).

**Colors and Preservatives** are detected and determined as described in Chapters XVII and XVIII.

**Total Acidity.**—Titrate 10 grams of the juice, diluted to 250 cc. with freshly boiled water, with tenth-normal alkali. Use phenolphthalein as

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indicator if the color of the juice will permit, otherwise delicate litmus paper. Calculate either as sulphuric acid or as the organic acid known to predominate.

One cc. of tenth-normal alkali is equivalent to 0.0075 gram tartaric acid, 0.0067 gram malic acid and 0.0064 gram citric acid.

**Determination of Total Tartaric Acid.**—Proceed as directed for wine, p. 731, using only 50 cc. of the sample diluted to 100 cc. and adding 20 instead of 15 cc. of alcohol.

**Determination of Malic Acid.**—*Dunbar and Bacon Method.*—Dilute a weighed or measured amount of the fruit juice, usually 10 grams, with quite a large volume of water, add phenolphthalein, and titrate with standard alkali to a decided pink color. Weigh or measure another portion of the liquid (75 grams or cc. is a convenient amount) into a 100-cc. graduated flask, and add enough standard alkali, calculated from the above titration, to neutralize the acidity. A slight excess of alkali is not objectionable. If the solution is dark colored, add 5 or 10 cc. of alumina cream. Dilute to the mark, mix thoroughly, and filter if necessary through a folded filter.

Treat about 25 cc. of the filtrate with enough powdered uranyl acetate so that a small amount remains undissolved after two hours, 2.5 grams usually being sufficient, except in the presence of large amounts of malic acid. In case all the uranium salt dissolves more should be added. Allow to stand for two hours, shaking frequently, filter through a folded filter until clear and polarize if possible in a 200-mm. tube or, if too dark, in a 100- or 50-mm. tube. Designate this solution and reading as A.

Treat the remainder of the original filtrate with powdered normal lead acetate until the precipitation is just complete, avoiding a large excess and consequent solution of lead malate. Cool in an ice bath and filter through a folded filter until clear. Warm the filtrate to room temperature and add a small crystal of lead acetate. If no precipitate forms, remove the excess of lead with anhydrous sodium sulphate, filter until clear, and polarize. Designate this solution and its polarization reading as B. Solutions which are sufficiently clear and contain less than 10% of sugar may be polarized directly without treatment with lead acetate.

If reading B is negative treat a portion of solution B with uranyl acetate in the manner already described and polarize. Designate this as C. If reading B is positive, reading C need not be made.

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Polarize all solutions at a uniform room temperature with white light, using the average of at least six readings and calculating to the basis of a 200-mm. tube. If reading C is numerically less than reading B, the latter should be discarded; otherwise use reading B in the subsequent calculation. Multiply the algebraic difference between this reading and reading A by 0.036, the product being the percentage of malic acid (C₄H₆O₆) in the solution as polarized.

Pratt's Modification.*—Place a weighed amount of juice, generally 100 grams, in a 500-cc. beaker and add, with vigorous stirring, two or three times its volume of 95% alcohol. The pectin bodies are precipitated and usually in such a form that after standing a few minutes they may be gathered into a coherent mass. Decant the liquid through a filter and wash the precipitate twice with 95% alcohol. Evaporate the filtrate in a current of air on the water-bath to about 75 cc. After cooling make up to 100 cc. in a measured flask, using 10 to 15 cc. of 95% alcohol and distilled water. The temperature when the volume is finally made up to the mark should be close to that at which the polariscope readings are to be taken. Treat this solution exactly as in the original method, except that no clarification is necessary.

Determination of Citric Acid.—Pratt Method.†—This method is applicable in the presence of malic and tartaric acids, but according to Bigelow and Dunbar ‡ does not give accurate quantitative results although it serves to show the presence or absence of citric acid. Willaman’s modification § is designed to correct the defects of the method but has not yet been rigidly tested. Dunbar and Lepper ‖ recommend the Stahre-Kunz method. The original Pratt method is here given pending further improvement or the introduction of a better method.

1. Apparatus.—This consists of a 500-cc. distilling flask provided with a small dropping funnel drawn down to a small opening and protruding ½ inch below the stopper. In the flask is placed a glass rod with a piece of small tubing ½ inch long, sealed on the lower end to insure steady ebullition. This small tube should be filled with air when the heating begins. A condenser preferably of the spiral type is connected with the flask.

† U. S. Dept. of Agric., Bur. of Chem., Circ. 88, 1912.
2. Denigès Reagent.—Add about 500 cc. of water to 50 grams of mercuric oxide; then add 200 cc. of concentrated sulphuric acid with constant stirring, and heat the mixture, if necessary, on a steam bath until the solution is complete. After cooling make up to a liter and filter.

3. Determination.—Weigh 50 grams of the fruit juice into a beaker and add 110 cc. of 95% alcohol to throw out the pectin bodies. After standing fifteen minutes filter and wash with 95% alcohol. Dilute the filtrate with water to approximately 50% alcohol content and add enough 20% barium acetate solution to precipitate the citric acid. Stir, let stand until the barium citrate partially settles, and filter. Wash twice with 50% alcohol to remove the greater part of the sugar present. Remove all alcohol from the precipitate and filter either by drying in the beaker used for precipitation or else by washing with ether before removing from the funnel. Add 50 cc. of water and 3 to 5 cc. of sirupy phosphoric acid to the beaker containing the filter-paper and precipitate and warm, thus dissolving the barium citrate completely. Filter into a 100 cc. measuring flask and wash up to the mark.

Measure an aliquot containing from 0.05 to 0.15 gram of citric acid, into the distilling flask, add 5 to 10 cc. of sirupy phosphoric acid and 400 cc. of hot water. Connect with the condenser, heat and when briskly boiling, add potassium permanganate solution (0.5 gram per liter), 1 to 2 drops per second, until a pink color persists throughout the solution. Distil off the acetone formed by the oxidation into a liter Erlenmeyer flask containing 30 to 40 cc. of Denigès reagent, continuing the distillation until 50 to 100 cc. remain in the flask. Boil the distillate gently under a reflux condenser for forty-five minutes after it turns milky. Filter hot through a Gooch crucible, wash the precipitate with water, alcohol, and finally with ether, and dry in a water-oven for half an hour. The weight of the precipitate multiplied by 0.22 gives the weight of citric acid.

FRUIT SYRUPS.

Two classes of these preparations are on the market, one for use in soda-fountains, and one for "family trade," intended as a basis for sweetened drinks to be diluted with water and sugar. Some are made exclusively from fruit pulp or juice and sugar, sterilized by heating and put-up in tightly sealed bottles, while others of the cheaper variety are more apt to be entirely artificial both in color and in flavor, deriving the latter principally from the wide variety of artificial fruit essences now available.
Commercial glucose is a frequent ingredient. The same classes of coal-tar dyes and antiseptics are found in these preparations as in the other fruit products. Citric or tartaric acid is frequently added to genuine fruit syrups to bring out the flavor and to imitation fruit syrups to better simulate the characters of the genuine product.

For purposes of comparison with such fruit-pulp preparations as may come to the analyst for examination, he is referred to the analysis of fruits found on pages 283 and 993.

NON-ALCOHOLIC CARBONATED BEVERAGES.

Soda Water.—Originally the beverage known as soda water was prepared by the action of an acid on sodium bicarbonate in solution and corresponded to what is now obtained by dissolving Seidlitz powders in water. Later it was found that water charged with carbon dioxide is not only more practicable commercially but also more acceptable to the palate, and this product was substituted for true soda water without change of name.

As dispensed by the pharmacist and confectioner in the United States, soda water consists of a syrup, variously flavored, mixed at the "fountain" with carbonated water. The syrup is first placed in the glass, then the carbonated water is drawn into it in a large stream and finally more added in a fine stream to mix and froth the liquid. Ice cream or liquid "cream" is used with certain flavors, eggs and milk in "egg chocolate," "egg shake" and other nutritious mixtures, a solution of calcium acid phosphate in "orange phosphate" and other phosphates—in fact there appears to be no end to the preparations and combinations introduced by ingenious vendors to quench the thirst, gratify the palate, and furnish nourishment in an easily digestible form.

Carbonated Water, the basis of all effervescent drinks, is prepared by charging ordinary water with carbon dioxide in a steel drum, known as the fountain. Formerly the gas was generated on the premises by the action of mineral acid on marble, but now it is obtained in liquid form in steel cylinders from mineral springs and the fermentation industries where it formerly went to waste.

The process of carbonating consists in allowing the gas to discharge into the water, rocking the fountain continually to aid absorption. A gauge indicates the pressure in the fountain, which should be about 170 pounds per square inch for soda water and somewhat less for ginger ale
2. *Denigès Reagent.*—Add about 500 cc. of water to 50 grams of mercuric oxide; then add 200 cc. of concentrated sulphuric acid with constant stirring, and heat the mixture, if necessary, on a steam bath until the solution is complete. After cooling make up to a liter and filter.

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**FRUIT SYRUPS.**

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from ginger (or ginger extract) with the addition of lemon juice (or lemon oil and citric acid) and carbonated water. Capsicum extract, known in solid form as capsicin, is frequently substituted in part for the ginger because of its greater pungency.

*Root Beer* was formerly brewed from a sweetened infusion of various roots and herbs, the gas being formed by a true fermentation process. A similar beverage is now made in the household, using so-called "root-beer extract," but the commercial product is commonly charged, like soda water, with carbon dioxide gas.

*Birch Beer*, formerly made by fermentation, is now merely soda water flavored with oil of birch or synthetic methyl salicylate.

*Sarsaparilla*, so called, is flavored with a mixture of oil of birch, natural or synthetic, and oil of sassafras. The dark color is due to caramel or other artificial colors.

*Lemon Soda* and *Orange Soda* are flavored respectively with terpeneless lemon and orange extract, the acidity being contributed by citric acid. Orangeade belongs in the same class. So-called blood orange soda is probably never made from blood oranges, the color being artificial.

*Vanilla Soda* is more correctly vanillin soda or vanillin and coumarin soda. The term cream soda applied to this colorless beverage is equally misleading.

*Strawberry Soda*, *Raspberry Soda* and other bottled beverages purporting to be made from fruits are commonly imitations flavored with ethers and colored with coal-tar dyes. So-called *Cherry Soda* is flavored with an extract of cherry bark or benzaldehyde.

**Sweeteners in Beverages.**—Sugar is the only proper sweetener for syrups of bottled beverages. Glucose because of its lower sweetening power is unsuited for the purpose, while saccharin and other chemical sweeteners are objectionable both because of their lack of nutritive properties and their possible injury to health. The use of saccharin, which has hitherto been extensive, is now prohibited in beverages entering into interstate commerce.

**Acids in Beverages.**—Citric and tartaric acids are used not only in imitation, but also in true fruit syrups to bring out the flavor. Lemon juice serves the same purpose, but is more expensive and does not keep so well. Calcium acid phosphate is a characteristic constituent of orange and other fruit phosphates.

**Preservatives.**—Sodium benzoate is the common preservative of bev-
erages, although its use is by no means universal. Formerly salicylic, boric and sulphurous acids and even fluorides were employed. A recent German patent names \( p \)-chlorobenzoic acid as a harmless preservative many times as effectual as benzoic acid.

**Artificial Colors.**—Cochineal, cudbear, caramel and the eight colors allowed by U. S. decisions are most commonly met with. The use of fuchsin, acid fuchsin, rhodamine, and other coal-tar colors has been largely discontinued.

**Foam Producers.**—Froth on soda water is cheaper to produce than the same bulk of liquid, furthermore it is sanctioned by custom.

*Soap-bark,* the bark of *Quillaja Saponaria,* a common foam producer, contains two saponins, sapontoxin and quilliac acid, both of which are poisonous. In addition these principles combine with the choleserin of the blood and if in excess dissolve the corpuscles.

*Commercial saponin,* prepared from *Saponaria officinalis,* and consisting largely of sapotoxin, is also extensively used.

Foam producers are also used in malt liquors.

*Glycerrhisin,* the characteristic principle of licorice, also serves as a foam producer.

**Habit-forming Drugs in Beverages.**—Caffein, extract of cola leaves, and cocaine are ingredients of certain proprietary syrups and beverages, contributing their well-known stimulating properties. The use of caffein is defended on the ground that it is the active principle of tea and coffee. Opponents of this drug have pointed out that tea and coffee are recognized as improper articles of diet for children and invalids, furthermore, the presence of other constituents tends to prevent the excessive use of these beverages. Again the presence of caffein in carbonated beverages is not usually known to the consumer, and he forms the habit without proper warning.

It would be difficult to find an argument in favor of the use of a drug so potent as cocaine or products containing cocaine.

**METHODS OF ANALYSIS.**

Transfer the sample to a flask and shake at intervals for an hour or two, at room temperature, thus removing most of the carbon dioxide. Use the liquid thus obtained for the several determinations, measuring out the portions, if desired, and calculating the weight from the specific gravity.
**VEGETABLE AND FRUIT PRODUCTS.**

Total Solids, Aeb, Acidity, and Individual Sugars are determined as directed for jams and jellies (pages 995 to 999) using 25 grams of the liquid except for the polarizations, which may be made on normal quantities.

Vanillin, Coumarin, Citral, and Methyl Salicylate are detected and determined by the methods described under the head of Flavoring Extracts, with such modifications as are necessitated by the absence of alcohol on the one hand and the greater dilution on the other. Methods for the detection of Ginger and Capsicum are given on page 952.

Detection of Colors, Preservatives, and Sweeteners.—See Chapters XVII, XVIII, and XIX.

**Determination of Phosphoric Acid.**—This determination is made in so-called "orange phosphate," "raspberry phosphate" and other beverages containing calcium acid phosphate.

Treat 25 grams of the liquid according to the method described on page 362, except that the entire residue, after ignition with magnesium nitrate, is used for the determination, without aliquoting.

**Determination of Alcohol.**—Follow the method prescribed for wines (page 687). The amount of volatile oil present is seldom sufficient to appreciably affect the results.

**Detection of Saponin.**—Of the various color tests that have been proposed none has been found absolutely characteristic, especially if glycerrhizin is present, although the reactions with sulphuric acid and Fröhde reagent are of considerable value. The hæmolysis test is believed to be reliable even in the presence of glycerrhizin. Whichever test is applied the saponin should be separated from interfering substances as follows:

I. **Extraction of Saponin by the Rühle-Brummer Method.**—In the case of soda water and other products containing organic or mineral acids (other than carbonic), to 100 cc. of the liquid add an excess of precipitated magnesium carbonate and filter. If dextrin is present, as in the case of malt liquors, evaporate 100 cc. of the liquid to 20 cc., precipitate with 150 cc. of 95% alcohol, let stand thirty minutes, then heat to boiling, filter, dilute the filtrate with water and dealcoholize, finally making up the solution to 100 cc.

To 100 cc. of the neutral, dextrin-free solution in a separatory funnel, add 20 grams of ammonium sulphate, 9 cc. of phenol and shake thoroughly. Draw off the watery layer and shake the phenol solution with a mixture

of 50 cc. of water, 100 cc. of ether, and (if necessary to avoid an emulsion) 4 cc. of alcohol. Allow to stand until the liquids separate, which usually requires twelve to twenty-four hours. Draw off the aqueous solution and evaporate nearly to dryness, finishing the drying either at 100° C. or in a desiccator, the latter being preferable if the residue is to be purified by treatment with acetone, which is usually desirable. Employ this extract, consisting of saponin and impurities, in the following tests:

II. Tests for Saponin.—1. Sulphuric Acid Test.—Rub up a portion of the extract with a few drops of sulphuric acid. Saponin is indicated by the appearance in a few minutes of a reddish color changing in half an hour to red-violet and finally to gray.

2. Fröhde Test.—Treat another portion in like manner with a few drops of a mixture of 100 cc. of concentrated sulphuric acid and 1 gram of ammonium molybdate. In the presence of saponin the drops in fifteen minutes become violet, changing later to green and finally to gray.

3. Foam Test.—Shake another portion of the extract with water and note its foam-producing properties.

In the presence of glycrrhizin none of the last three tests is reliable.

4. Haemolysis Test.—This process is recommended by Rusconi,* Sormali,† and Rhüle.‡ The following details are given by Rhüle and are based on the method as described by Gadamer: §

(a) Reagents.—(1) Physiological Salt Solution.—Dissolve 8 grams of sodium chloride in water and make up to one liter.

(2) One per cent Defibrinated Blood.—Shake vigorously fresh ox blood in a sterilized, salt-mouth, 500-cc. bottle with 20 glass beads 5–7 mm. in diameter. Separate from the clot of fibrin and store in a sterilized container in a refrigerator. Properly cared for it should keep for several days.

Dilute with 100 volumes of physiological salt solution for use.

(3) One per cent Blood Corpuscles.—Centrifuge 100 cc. of the 1% defibrinated blood in physiological salt solution, pour off the clear solution containing the cholesterol and make up again to 100 cc. with the salt solution. This preparation is more sensitive than solution, (2).

(b) Process.—Dissolve about 0.1 gram of the extract in 25 cc., of physiological salt solution, filter, and shake 1, 2, and 3 cc. of this solution

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‡ Ibid., p. 566.
in small test-tubes with 1 cc. portions of 1% defibrinated blood. If saponin is present the liquid becomes clear in from a minute to an hour or two, depending on the amount of saponin in the beverage and the number of cubic centimeters of the solution used.

As a confirmatory test dissolve 1 mg. of cholesterol in a small amount of ether, shake with 10 cc. of the solution of the extract in salt solution, heat at 36° C., for a few hours to remove ether, avoiding concentration, and treat portions of this solution with 1% defibrinated blood as above described. Cholesterol destroys the haemolytic action of the saponin, hence the liquids should not become clear in these tests. In order to exert this influence cholesterol should be present to the extent of 1 part to 5 parts of saponin.

If only a small amount of saponin is present the haemolytic action can best be noted under a microscope magnifying to 300 diameters. Mount a drop of the solution of the extract in salt solution and place a drop of either solution (2) or (3) in contact with it. The saponin causes the corpuscles in contact with it to swell, then become strongly refractive, and finally dissolve.

Muller-Hössly* neutralizes 500 to 1000 cc. of the sample and blows a current of air into it through a glass tube extending to the bottom of the container, collects the foam which froths over, and makes the test on the liquid obtained by the subsiding of the foam. The saponin in the foam is in much greater amount than in the original liquid.

**Determination of Caffein.—Fuller Method.†**—Weigh 50 grams or measure an equivalent volume into a small beaker, add 5 cc. of concentrated ammonium hydroxide, allow to digest overnight; then add 2 cc. more of ammonium hydroxide, heat for two hours, transfer to a large separatory funnel, dilute with 3 volumes of acid, add 5 cc. of ammonium hydroxide and shake out with four successive portions of chloroform, each of 50 cc. In case any dyestuff is removed by the chloroform, shake out with a saturated solution of sodium bisulphite, which will remove some of the color.

Distil off the bulk of the chloroform and evaporate the remainder in a porcelain dish. Dissolve the residue in 25 cc. of 2% sulphuric acid, shake out with five portions of 15 cc. each of chloroform, filter the combined chloroform solutions into a flask, distil off the bulk of the chloroform and evaporate in a tared dish; dry at 100° C. and weigh.

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If the caffeine is not pure, dissolve in 15 cc. of 10% hydrochloric acid, add an excess of a solution of 10 grams of iodine and 20 grams of potassium iodide in 100 cc. of water, allow to stand overnight, filter, and wash twice with 10 cc. of the iodine solution. Transfer filter and precipitate to the original precipitation flask, add sufficient sulphurous acid to dissolve the precipitate, heating gently, filter into a separatory funnel, wash three times with water, and add ammonium hydroxide in excess; shake out four times with 15 cc. portions of chloroform, and filter the chloroform extracts into a flask, using a 7 cm. filter and keeping the funnel covered with a watch glass. Wash the filter with 5 portions of 5 cc. of chloroform. If the chloroform extract is colored, concentrate, add a small amount of animal charcoal, rotate several times and filter. Distil off part of the solvent and evaporate the remainder in a tared dish, dry at 100° C., and weigh.

Detection and Determination of Cocaine.—Fuller Method.*—To 200 cc. of the sample in a large separatory funnel, add concentrated ammonium hydroxide to alkaline reaction, and shake out with three portions of 50 cc. each of Prolius mixture (4 parts ether, 1 part chloroform, 1 part alcohol), collecting the solvent in another separatory funnel. If desired the aqueous solution may be reserved for the detection of salicylic and benzoic acids and saccharin. Filter the combined Prolius extracts into an evaporating dish, and evaporate on a steam bath, removing the dish as the last traces of solvent disappear. Dissolve the residue in normal sulphuric acid, transfer to a separatory funnel and shake out four times with 15 cc. portions of chloroform; wash the combined chloroform solutions once with water, reject the chloroform, and add the water extract to the original acid solution. Add 10 cc. of petroleum ether, boiling at 40° to 50° C., and shake; draw off the acid layer, rejecting the petroleum ether, add concentrated ammonium hydroxide in excess and shake out three times with 15 cc. portions of petroleum ether, collecting the ethereal solutions in another separatory funnel. To the latter add 10 cc. of water and shake thoroughly; reject the water extract and filter the petroleum ether into a beaker, washing twice with 10 cc. portions of the solvent. Evaporate over a steam bath, using a fan. By this method, if coca alkaloids are present, a nearly colorless residue will be obtained, which will finally crystallize on standing.

Dissolve the residue in petroleum ether and divide into four portions, one of which may be small. Evaporate the solvent and to the small

portion add a few drops of normal sulphuric acid, warm gently, filter into a test-tube, and add a drop of potassium mercuric iodide test solution (Meyer's reagent). A precipitate indicates an alkaloid, but does not identify it as cocaine; if no precipitate forms, cocaine is not present and further test is unnecessary.

To another portion add a few drops of concentrated nitric acid, and evaporate on a steam bath until the acid is all driven off, then add a few drops of half normal alcoholic potash and note the first odor that comes off, which, if cocaine is present, is that of ethyl benzoate.

The residue of the third portion should be applied to the end of the tongue by rubbing with the finger. Cocaine will cause a numbness which is not apparent immediately, but develops gradually, and persists for a longer or shorter time according to the amount present.

Remove a portion of the fourth residue to a microscopic slide, add a drop or two of gold chloride test solution, and stir vigorously, noting the character of the crystals under the microscope.

All the above tests should be checked by controls on pure cocaine.

If a quantitative determination of coca alkaloids is desired the residue after evaporating the petroleum ether should be weighed, then, as a check on the gravimetric determination, warmed in 50 cc. of fiftieth-normal sulphuric acid until dissolved, cooled, and titrated with fiftieth-normal potassium or sodium hydroxide, using cochineal as indicator. The factor for cocaine is 0.006018.

**Determination of Caffein and Detection of Cocaine and Glycerol. — Fuller Method.** — Weigh 50 grams of the sample into an evaporating dish, add 5 cc. of concentrated ammonium hydroxide, cover with a watch glass and allow to stand twelve hours. Add 2 cc. more of ammonium hydroxide and evaporate on steam bath. Warm the residue with 25 cc. of 95% alcohol on the steam bath, cool, and pour off the alcohol into another evaporating dish, repeating the treatment four times. Evaporate the combined alcoholic extract, dissolve the residue at 25 cc. of 2% sulphuric acid, transfer to a separatory funnel and shake out 5 times with 15 cc. portions of chloroform.

Reserve the acid liquid for subsequent tests for cocaine and glycerol.

Distil off most of the chloroform, evaporate in a dish on a steam bath, dissolve the residue in 10% hydrochloric acid and transfer to a small flask. Add to the acid solution an excess of iodine solution (10 grams
iodine and 20 grams potassium iodide in 100 cc. of water), rotate flask, allow to settle overnight, filter, and wash flask and precipitate twice with the iodine solution, then transfer filter and precipitate to the flask. Heat gently with sufficient sulphurous acid solution to dissolve the precipitate, filter into a separatory funnel, cool, add excess of concentrated ammonium hydroxide, and shake out four times with 15 cc. portions of chloroform. Filter the chloroform extract into a flask, using a 7-cm. filter in a small funnel covered with a watch glass, or filter through cotton plugged in the stem of the separatory funnel. Decolorize the chloroform, if necessary, with animal charcoal, distill off most of the chloroform, then evaporate in a tared dish over steam, dry at 100° C. and weigh.

Add an excess of concentrated ammonium hydroxide to the solution from which the caffeine was extracted, shake out three times with petroleum ether, boiling at 40° to 60° C., filter ether solution, divide into four parts, evaporate, and test for cocaine as described in the preceding method.

Evaporate the aqueous solution from the cocaine extraction with milk of lime and proceed as in the determination of glycerol in wines (page 734). The glycerol thus obtained will be only an approximation to the true amount.
CHAPTER XXII.

DETERMINATION OF ACIDITY BY MEANS OF THE HYDROGEN ELECTRODE.

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The usual methods of determining acid and alkali are frequently inapplicable in food analysis because the color change of the indicator, by means of which the end point is observed, is masked by the presence of colored substances or by turbidity. In such cases the use of the hydrogen-electrode method is essential. Furthermore, there are many titrations in which it is not so important to know the total quantity of acid present as it is to determine exactly the concentration of hydrogen ions in the original solution. That is, it is desirable to determine the actual acidity as distinct from the total available acidity. A large part of the latter may be present originally in the form of undissociated molecules, and therefore inactive as acid until alkali is added. The hydrogen electrode method offers a simple means for such a determination. Finally, there are many occasions when the analyst wishes to prepare a solution of definite acidity which may be far from the neutral point, and yet also far from being so acid or so alkaline as to be readily analysed. In such cases also the hydrogen electrode is of great convenience in that it indicates constantly the actual acidity of a solution at any moment, and acid or alkali need therefore to be added only until the instrument records the proper concentration. All three problems are frequently met with in courses of food analysis.

In addition, indicator titrations are occasionally impossible because the salts present in the material to be titrated exert such a strong "buffer" action—as in milk, for instance, or in rhubarb juice—that the color change of the indicator is so gradual as to be quite unreliable. Related to this is the fact that the choice of the proper indicator is exceedingly important in such cases. The common indicators may all change at a degree of acidity which wholly unsuits them for some particular titration. And, lastly, the usual titration can give no information as to which acid or which
alkali is present in the solution that is being analysed. Thus fruit acids are empirically reported as per cent citric, malic or sulphuric regardless of the acid or mixture of acids present. On the other hand, the electrometric method frequently reveals the characteristics of the acid that is being determined. For all these reasons, then, a simple form of the hydrogen electrode apparatus is to be recommended as part of the equipment of any food laboratory.

**Principle of the Method.**—The first principle involved in this method of determining acidity is that every aqueous solution must have a definite concentration of hydrogen ions. Even pure water can be regarded as an acid, and equally well as an alkali, in the sense that water contains both hydrogen and hydroxide ions in definite concentration. The dissociation of water into its ions is weak, yet accurate measurements have shown that about one water molecule in five hundred million is dissociated into its ions. In other words, the concentration of hydrogen ions in water is very close to $10^{-7}$ grams per liter. Since each molecule of water on dissociation gives rise to one hydrogen ion and one hydroxide ion, the concentration of hydroxide ion in water is also $10^{-7}$ gram ions per liter, i.e., both are $10^{-7}$ normal. The product of the two concentrations is consequently $10^{-14}$.

According to the simple principles of chemical equilibrium these two concentrations must bear a definite ratio toward each other at all times. That is, in the reaction represented by the equation $H_2O \rightleftharpoons H^+ + OH^-$, definite equilibrium concentrations of the reacting substances must always be obtained such that the velocity of the forward reaction is the same as that of the reverse action. This can be the case only if the concentration of hydrogen ions multiplied by the concentration of hydroxide ions be constant; i.e., if, using the usual chemical symbols, $(H^+)(OH^-) = K = 10^{-14}$. This constant is, of course, the dissociation constant of water, and represents the product of the concentrations of hydrogen and hydroxide ions expressed in normality.

This constant must hold good for every solution which contains water, and thus for all aqueous solutions, irrespective of the amount of hydrogen or hydroxide ions added from other sources. That is to say, in a normal solution of a strong acid, the hydrogen ion concentration is one, or $10^0$; substituted in the above equation, the hydroxide concentration must be $10^{-14}$ in order that their product remain $10^{-14}$. Similarly a hundredth normal solution of a strong acid would have a concentration of hydroxide equal to $10^{-12}$. Strong acids therefore contain definite concentrations of hydroxide ions. At the other end of the scale, alkalis similarly contain
definite concentrations of hydrogen ions. The variation of hydrogen with hydroxide is represented in the following table:

<table>
<thead>
<tr>
<th>$\text{II (H}^+\text{)} = 10^1$</th>
<th>$(\text{OH}^-) = 10^{-18}$</th>
<th>$P_H = -1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^6$ (N)</td>
<td>$10^{-14}$</td>
<td>0</td>
</tr>
<tr>
<td>$10^{-1}$ (0.1N)</td>
<td>$10^{-11}$</td>
<td>1</td>
</tr>
<tr>
<td>$10^{-2}$ (0.01N)</td>
<td>$10^{-13}$</td>
<td>2</td>
</tr>
<tr>
<td>$10^{-3}$</td>
<td>$10^{-13}$</td>
<td>3</td>
</tr>
<tr>
<td>$10^{-4}$</td>
<td>$10^{-12}$</td>
<td>4</td>
</tr>
<tr>
<td>$10^{-5}$</td>
<td>$10^{-11}$</td>
<td>5</td>
</tr>
<tr>
<td>$10^{-6}$</td>
<td>$10^{-9}$</td>
<td>6</td>
</tr>
<tr>
<td>$10^{-7}$</td>
<td>$10^{-7}$</td>
<td>7</td>
</tr>
<tr>
<td>$10^{-8}$</td>
<td>$10^{-7}$</td>
<td>8</td>
</tr>
<tr>
<td>$10^{-9}$</td>
<td>$10^{-8}$</td>
<td>9</td>
</tr>
<tr>
<td>$10^{-10}$</td>
<td>$10^{-8}$ (0.01N)</td>
<td>10</td>
</tr>
<tr>
<td>$10^{-11}$</td>
<td>$10^{-9}$</td>
<td>11</td>
</tr>
<tr>
<td>$10^{-12}$</td>
<td>$10^{-9}$ (0.1N)</td>
<td>12</td>
</tr>
<tr>
<td>$10^{-14}$</td>
<td>$10^{-1}$ (N)</td>
<td>13</td>
</tr>
<tr>
<td>$10^{-18}$</td>
<td>$10^1$</td>
<td>14</td>
</tr>
</tbody>
</table>

The negative exponent of 10 in these concentration figures for the hydrogen ion is the distinguishing factor for each case and has come to be used directly in this sense under the name of "$P_H$".

Pure water stands in the center of this scale in that its hydrogen ion concentration is exactly equal to its hydroxide concentration, both being $10^{-7}$. Water is therefore neutral, being as acid as it is basic. This is the exact neutral point, though it is seldom indicated by the indicators in general use. Most indicators will give either their "acid color" or their "alkali color" in water solution. Methyl orange, for instance, shows alkali in pure water, and phenolphthalein shows acid in pure water. Litmus and rosolic acid are two indicators that do change at the neutral point.

While each indicator is suited for the determination of some one value of $P_H$, it is obvious that no one indicator can be used to follow the change of hydrogen and hydroxide ion concentration when a solution is titrated, i.e., when the hydrogen ion concentration may vary all the way from $10^{-7}$ to $10^{-14}$. Each indicator has its own definite changing point, and will mark only the point at which that concentration is attained. The changing points for methyl orange and for phenolphthalein are indicated in Fig. 3. The hydrogen electrode method, however, records on a scale the concentration of hydrogen ions at all times, and it is thus possible to follow continuously the change beginning with strong acid all the way to
strong alkali or vice versa. The actual hydrogen ion concentration is indicated at every instant.

Theory of the Method.—The theory of the hydrogen electrode is familiar. Its details need not be discussed here as they are available in any text-book of physical chemistry. Essentially the method consists in the measurement of the voltage between a platinum electrode saturated with hydrogen and the acid solution. The platinum electrode is coated with a layer of platinum black which is allowed to become saturated with hydrogen gas. Hydrogen is readily soluble in platinum black so that such an electrode is essentially a “hydrogen electrode.” That is, for all practical purposes it acts like a rod or electrode of hydrogen inserted into the solution. The other electrode, which is to make direct contact with the solution, i.e., with the hydrogen ions, must be one in which the transition from solution to the metallic connecting wire is made under definite and constant electrical conditions. For this purpose a “calomel cell” is used. Thereby the potential of the hydrogen ions is communicated to the rest of the system by, first, a solution of potassium chloride, then mercurous chloride, “calomel” solution, then calomel paste in contact with metallic mercury, which in turn contains the connecting wire.

In such a system the potential between the coated platinum or hydrogen electrode and the mercury is given by the equation:

\[ E = 0.058 \log \left( \frac{1}{c} \right) + 0.283, \]

where \( c \) represents the actual concentration of hydrogen ions in the solution.

Transposing,

\[ \log c = -\left(\frac{E - 0.283}{0.058}\right), \]

and

\[ \frac{P_H}{c} = \left(\frac{E - 0.283}{0.058}\right). \]

\( E \) may then be read directly in volts on a voltmeter and the equation needs only to be solved for \( c \) or for \( P_H \) in order to give the hydrogen ion concentration or “actual acidity” of any unknown solution. The relation between \( E \) and \( c \) is linear, and the variation of one with the other may be calculated once for all and embodied in a table or curve, as is shown in the figures of this chapter. Indeed the voltmeter itself may conveniently be graduated to read in values of \( c \) directly, as well as in values of \( E \). Titration consists then in following the change in \( E \) as \( c \) is varied by the addition of acid or alkali to the solution.
The Apparatus.—The necessary apparatus consists of the hydrogen electrode, the calomel cell, and a potentiometer arrangement to measure the potential between them. For accurate work an accurate potentiometer is necessary, but for the usual laboratory determinations a potentiometer can
be readily built up from an ordinary dry cell, a 100-ohm variable resistance, a voltmeter, and a sensitive galvanometer which will determine when no current is passing. This galvanometer should have a sensitivity of one megohm. A diagram of the arrangement of these instruments is shown in Fig. 120b and a photograph of a typical assembly in Fig. 120a. B represents a dry cell, and is connected directly through the resistance R, and a knife switch to form a complete circuit which must be closed whenever the instrument is in use. By means of the variable contact on the resistance, various potentials may be drawn from this main circuit and sent through the side circuit, which comprises the calomel cell C, the solution to be titrated, the hydrogen electrode H, the galvanometer G, and a spring contact switch. The resistance is set at such a point that the galvanometer indicates the passage of no current. In that case, the potential being drawn from the main circuit is exactly equal and opposite to the potential from the hydrogen electrode-calomel electrode system. In order to measure this potential, a voltmeter V is placed in parallel with this side circuit, and at all times measures the potential. The procedure consists, therefore, simply in adjusting the resistance until on closing the contact key the galvanometer shows no current, and then reading the voltage. As suggested above, the
DETERMINATION OF ACIDITY

voltmeter may be graduated to read directly in units of hydrogen ion concentration rather than in volts.

Details of the Apparatus.—1. The Hydrogen Electrode.—This is a platinum wire 1 mm. in diameter, somewhat flattened at the lower end, which has been sealed into a small glass tube from which a copper wire leads to the rest of the circuit. This platinum wire must, when immersed in the solution, be about half covered by a larger tube which serves as a sort of bell to keep the upper half of the wire immersed in hydrogen gas while the lower half dips into the solution. The hydrogen is admitted to this bell-tube by a T-joint, and during operation bubbles continuously through the solution from under the bell at the rate of about two bubbles per second. The platinum wire must, before use and before insertion in the bell, be covered with a deposit of platinum black. This is done by first cleaning the wire thoroughly in chromic acid solution or in aqua regia if necessary. Platinum is then deposited on this wire by dipping it into a dilute solution of platonic chloride, and connecting the electrode to the negative pole of a dry cell, the positive being connected to another short piece of platinum wire which dips into the solution and forms the anode in the electrolysis. Deposition for fifteen minutes is ample, but it is desirable that the direction of the current be reversed frequently, as often as twice a minute, in order to give a smooth uniform coating of platinum, which should be black and velvety in appearance. The occluded chlorine may be removed by dipping the electrode into a ferrous or other reducing solution. The electrode is then washed with distilled water, and should thereafter always be kept moistened. When not in active use it should be kept in distilled water. If the electrode dries, the platinum deposit must be wiped with a dry cloth or more thoroughly removed, and a new layer of platinum black must be deposited. The electrode in this condition will absorb hydrogen from hydrogen gas and constitute in effect a hydrogen electrode. Time may be economized however, by saturating the electrode with hydrogen artificially by using this electrode as the cathode in an electrolysis of sulphuric acid. Hydrogen is thus evolved on the cathode, and serves to saturate it rapidly. This saturation should be repeated whenever the electrode is removed from its contact with pure hydrogen gas. The coating with platinum black should be serviceable for several weeks before it requires replacement. If solutions containing viscous materials or adhering precipitates are used, the platinum layer needs to be replaced more often.

This form of electrode may be purchased from supply houses. Other forms are also in use, particularly some in which the platinum is in the form
of a large foil or strip. This form is more stable in use but requires a much longer time to become saturated with hydrogen and is troublesome in solutions containing precipitates or other solid or viscous materials such as cream or fruit shreds. For such cases a fine platinum gauze may be attached to the glass bell that surrounds the electrode to prevent its clogging, particularly if some stirring device is used. A gold electrode coated with palladium black is probably the most effective form of hydrogen electrode.

2. The Calomel Electrode.—A calomel electrode may be made up by any of the various methods recommended in text-books of physical chemistry. The forms of cell used vary widely. The simplest is a test-tube with a two-hole rubber stopper, fitted with tubes, one of which leads to the solution to be titrated, and the other of which holds a glass tube forming electrical connection with the mercury in the bottom of the test-tube by means of a wire sealed through the glass. The form to be recommended is one in which electrical connection from the mercury is made by a platinum wire sealed directly through the glass where the latter holds the mercury. The tube should have a side-arm forming a bridge to the solution, and unless a fine capillary is used, this side-arm should contain a glass stop-cock which is kept loosely closed but not greased. The calomel electrode tube should have another side-arm placed somewhat higher through which additional potassium chloride solution can be introduced. Finally, it should have a wide opening through which it can be filled, but which should be tightly closed after filling by means of a well-fitting ground glass stopper.

To fill the cell it should be thoroughly cleaned and rinsed with a normal potassium chloride solution. About 3 cc. of carefully purified mercury are then placed in the bottom of the cell. Above this is put a layer of mercury-calomel paste. This is prepared by rubbing together in a mortar pure "calomel," mercurous chloride, and metallic mercury with a small amount of the potassium chloride solution. When this paste is in place it is covered with a normal solution of potassium chloride which has been saturated with calomel. A large quantity of accurately normal potassium chloride solution should be made up, and after preparation should be thoroughly shaken with calomel in order to saturate it with that substance. The calomel electrode tube should then be filled up with this solution, leaving only a small air bubble at the top. The tube should be well stoppered, and permanent connection should be made through the upper side-arm with a reservoir bottle containing the excess of potassium chloride.
solution. Before each period of use a small quantity of the potassium chloride solution should be allowed to run through the calomel cell in order to wash out the lower side-arm, which constitutes the electrical connection with the solution to be titrated, and which will otherwise gradually become filled with materials from the latter solution by means of diffusion.

3. The Electrical Instruments.—Three electrical instruments are required, connected as shown in Fig. 120b, a variable resistance, a voltmeter, and a galvanometer. There are many varieties of resistances or rheostats on the market. Any form which permits the continuous variation of the resistance is satisfactory. The tubular wire rheostats of about 100 ohms total resistance are most convenient, but should be long enough to have at least 150 turns of wire in order to allow delicate adjustment of the end point. The voltmeter should have a total range of 1.25 volts, which is the maximum obtainable from a dry cell, and should be divided into hundredths of volts. The galvanometer, or other instrument used to detect the passage of current through the solution being titrated, is the only one of these instruments that needs to be sensitive. It should have a sensitivity of at least 1 megohm. There are several types of portable direct-reading galvanometers on the market with a sensitivity as great as this. By the use of the lamp and scale method, more sensitive and more expensive instruments may also be used with convenience. In very accurate work in which potential readings are to be made to millivolts, some form of electrometer is often used, such as the capillary electrometer or the quadrant electrometer. These are not required, however, for ordinary titration. The connections are shown in Fig. 120b, which is self-explanatory. It should be noted, however, that the short thick line of the battery, B, represents the positive or carbon pole of the dry cell. It is to this pole that the positive terminal of the voltmeter and the calomel cell connection are made.

Several complete assemblies of this apparatus are on the market. The most accurate, which can be depended upon to millivolts, is that designed by Dr. W. T. Bovie and manufactured by the Leeds & Northrup Co., of Philadelphia. This makes use of the quadrant electrometer, and is provided with a temperature compensating device. An apparatus designed by Dr. G. L. Kelley, can also be adapted to this purpose, and is sold by Arthur H. Thomas, of Philadelphia, Pa. The Central Scientific Co., of Chicago, has assembled the simplest forms of the various required instruments on a single board, the result being inexpensive and well suited for ordinary analytical work.
The Titration.—The solution to be titrated is placed in a sufficiently large beaker, the calomel electrode as above prepared is inserted, and the hydrogen electrode, platinized and saturated with hydrogen, is also inserted. A stream of hydrogen is allowed to pass over the hydrogen electrode and bubble through the solution continuously during the titration. The hydrogen should be pure, best made by electrolysis or generated from pure zinc and purified by passing through an alkaline solution. It is usually desirable to stir the solution by some extraneous stirring device. Electrical connections are made and preliminary observations of the voltage may be taken, although at the beginning of the titration the electrode is usually not saturated and does not give a constant voltage reading during the first few minutes. If the electrode has been saturated by means of the electrolysis of sulfuric acid, however, not more than a minute should be required to determine the original $P_N$ or "actual acidity." If the solution is to be titrated acid or alkali may now be added, and readings of the voltage may be taken almost at once. The electrode action is most satisfactory when the potential is built upwards, that is, when alkali is added to acid. Beginning with a definite quantity of acid, the data to be recorded are the amounts of alkali added and the voltage at each addition. These data are best comprehended by plotting them graphically, recording voltage against cubic centimeters of alkali added. Several such curves are reproduced here-with.

Typical Curves.—Curve I, Fig. 120c, represents the titration of 25 cms. of tenth-normal hydrochloric acid solution with tenth-normal sodium hydroxide. Ordinates on this curve represent acidity. The voltage scale is represented on the left while the corresponding concentrations of hydrogen ions are given on the right. The voltage $0.69$ is that of the neutral point, where $(H^+) = (OH^-) = 10^{-7}$. The higher the voltage, the lower the hydrogen ion concentration and the greater the alkalinity. The abscissae represent volumes of the alkaline solution added.

The original voltage shown by Curve I is $0.35$, which represents a tenth-normal hydrogen ion concentration. The curve shows that the first quantities of alkali added have little effect on the hydrogen ion concentration. The alkali is used up in the formation of sodium chloride and the fraction of the total acid used is so small that there is little change in the hydrogen ion concentration and in the voltage. As more and more acid is neutralized, however, every drop of alkali causes a correspondingly larger proportional change in the hydrogen ion concentration and the voltage rises more and more rapidly. When a voltage of $0.45$ is attained and the acid
is less than one-thousandth normal the addition of a few drops of alkali causes a marked change in the hydrogen ion concentration that the voltage rises rapidly and indeed abruptly. At 24.8 cc. of alkali, the potential rises to beyond the neutral point and this quantity of alkali therefore represents the total amount of acid originally present. This figure, 24.8, is the one that would be obtained by the usual indicator titration and represents the amount of tenth-normal alkali necessary to neutralize the acid originally present. The acid was therefore very slightly weaker than tenth-normal. Beyond this point the addition of alkali increases the hydroxide ion concentration and decreases the hydrogen concentration in a lesser proportion and the voltage therefore rises more gradually, tending finally to reach the voltage of a tenth-normal alkali solution, which is slightly less than 1 volt. The further addition of alkali is, however, unnecessary, as the last part of the curve represents merely the dilution of tenth-normal alkali by the volume of solution present in the titrating vessel.

The center of the vertical rise in voltage at about 25 cc. of alkali needs further attention. It will be seen that the central point of the vertical line lies at a voltage of about .69. This is the voltage given by a strictly neutral solution and it indicates the point at which hydrogen and hydroxide
ions are in equal concentration. Since the central part of the vertical rise of this curve here falls exactly at the true neutral point it follows that the products of the reaction here used are such that they do not react with water to give a product which is itself acid or alkaline. The products of the particular reaction shown by this curve are, of course, sodium chloride and water, and it is obvious that sodium chloride does not hydrolyze to give an acid or a basic product.

Curve 2, Fig. 120c, shows the titration of the same quantity of tenth-normal acetic acid with the same alkaline solution. The curve shows that the same quantity of alkali is required for neutralization and hence that the total acidity of the acetic acid was the same as that of the hydrochloric acid, both being tenth-normal. The course of the voltage during the early part of the titration, however, is quite different in this case. In the first place, the original voltage is higher, indicating a lower actual hydrogen ion concentration in the tenth-normal acetic acid, due, of course to the fact that acetic acid is but slightly dissociated. Its "actual acidity" is, indeed hardly more than thousandth normal. The second point worthy of notice is that in the very beginning of the titration the rise in voltage is much more rapid than in the case of the hydrochloric acid. This means that the addition of alkali has here an abnormally large effect in decreasing the hydrogen ion concentration. This is due, of course, to the fact that as soon as sodium hydroxide is added, sodium acetate is formed which is highly dissociated and therefore liberates a relatively large number of acetate ions. These, according to the principle of equilibrium have an immediate effect in depressing the already small ionization of the acetic acid, so that the acid which is present becomes still less dissociated; hence it allows still fewer hydrogen ions and hence causes a noticeable rise in the voltage. This effect is marked only during the first 8 cc. and thereafter the trend of the curve is about the same as that in the titration of hydrochloric acid. Complete neutralization occurs at the same point, and the last part of the curve coincides with that of the hydrochloric acid since it represents only the dilution of the tenth-normal sodium hydroxide by the sodium acetate solution.

A third point to be noted is that the length of the vertical portion of this curve is much less than in the other case with the consequence that the center of this vertical portion lies not at a voltage of .69 but rather at about .76 volt. Now the center of the vertical portion represents the hydrogen ion concentration when exactly equivalent quantities of sodium hydroxide and of acetic acid are present; that is, it represents the conditions when only
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Water and sodium acetate are present. But sodium acetate hydrolyzes to some extent in water solution giving rise to undissociated acetic acid and thus allowing freedom to an excess number of hydroxide ions. In common terms, sodium acetate gives a basic reaction. This reaction is indicated on this curve by the fact that the center of the vertical position of the curve is at .76 volt, corresponding to a hydrogen ion concentration between $10^{-8}$ and $10^{-9}$.

For this titration phenolphthalein is usually employed as indicator. The concentration of hydrogen ion, at which this indicator changes, is seen from Fig. 120d to be such that it is well suited for this purpose. It does not change color at the neutral point, but it does change at a point corresponding to the hydrogen ion concentration of a solution of sodium acetate in water. It is therefore the correct indicator for this purpose. Litmus would not do. Nor would methyl orange, which changes quite on the acid side of neutrality, and is therefore fitted only for titrations of strong acids with weak bases, since these give salts which hydrolyze in water to liberate hydrogen ions, and thus have an “acid reaction.”

The Titration of Milk.—The curves on Fig. 120d represent titrations carried out with a sample of milk at various times. Curve 1 represents the addition of tenth-normal sodium hydroxide to 25 cc. of fresh milk. The original voltage is .68. The milk is therefore very slightly acid—almost imperceptibly so. The true neutral point is reached with 1.5 cc. of alkali, but it is doubtful whether this quantity has any actual significance, for the steepest rise in the curve comes later at about 5.5 cc. and a voltage of .8. This is probably the point corresponding to sodium lactate. Thereafter, the rise of the curve is more gradual, but the entire curve is notably more flattened than the curves of the strong acids heretofore used. This is no doubt due to the presence of salts, especially the salts of weak alkalis and weak acids like the calcium phosphates. The data obtained from this curve are more reliable than those obtained by the usual indicator titrations used in commercial laboratories. The first point, for instance, is usually determined by the use of litmus, which changes very gradually, and gives a much less accurate determination of the actual hydrogen ion concentration. The second point is determined by the use of phenolphthalein which changes at an acidity corresponding to a voltage of .8. The opacity of milk hinders an accurate determination of the color change.

The same sample of milk was kept on ice and its actual hydrogen ion concentration was determined from day to day. The voltage varied as follows:
After a week, therefore, the acidity had increased so that the milk showed a hydrogen ion concentration of about $10^{-4}$, that is, the milk was thousandth normal in actual hydrogen ion concentration. This acidity, however, is due to lactic acid which is but slightly dissociated and the total acid present is undoubtedly more than this quantity. That this is true is shown by curves 2 and 3 of Fig. 120d, which represent titrations carried out on this sample on June 23 and June 24 respectively. The general form of these curves is the same as that of the first titration on this sample, being, however, somewhat more flattened. Total neutralization of the acid is reached again at about .8 volt corresponding to 18.6 cc. of alkali on June 23d. By the next day 22.3 cc. were required to reach the same voltage. The difference is a measure of the growth of lactic acid during the twenty-
four hours that had elapsed. The original voltage or "actual acidity" is, however, an equally good measure of the souring of the milk, and can be readily and speedily determined.

When milk has become sour or when it is rich in cream, the electrode tends to become clogged with the solid materials unless it is protected by a gauze as suggested above.

Tea and Coffee.—Fig. 120e represents the titration of samples of tea and coffee brews. Coffee is obviously more acid both in its actual hydrogen ion concentration, which is fairly high, and in its total acid. The curve for tea, on the other hand, is much flatter and indicates the presence of weaker acids and of more basic salts. The interesting portions of these titrations are in the voltages lying between 0.6 and 0.8 and the titration should be carried on with hundredth-normal alkali instead of with tenth-normal.

The Acidity of Fruit Juices.—For the titration of fruit juices, these are prepared in the usual way by pressing out the juice and straining through a fine cloth or filter. In all cases represented here by curves 25 cc. of fruit juice were used, though it is possible and often necessary to use a smaller quantity. The analyses represented are single instances chosen at random and make no claim to being representative for the different varieties of fruit.
Lemon and Strawberry.—Fig. 120f represents the titration of two common acid fruits, the lemon and the strawberry. It is noticeable that the actual acidity of the strawberry is greater than that of the lemon, being more than hundredth-normal. Yet the total acidity of the lemon is almost five times that of the strawberry. Twenty-five cc. of fruit juice were taken; hence the lemon is almost normal in total acid in that 22 cc. of normal alkali were required to neutralize it. The curve for the lemon is a typical curve for citric acid. The long sloping portion of the curve running from zero to 20 cc. represents the gradual neutralization of the three hydrogens that comprise the acid of this fruit. No distinct vertical parts of the curve are noticed because the reaction of the second hydrogen begins before that of the first is complete, and that of the third also begins very soon.

The Citric Fruits.—Fig. 120g shows this same titration of the strawberry as executed with one-tenth normal alkali. On the same figure appear the curves representing the orange, the grape fruit and the tomato. The strawberry is the most acid of these four fruits, especially in its actual acidity. Citric, salicylic and malic acids are present. The total acid of the orange is greater than that of the grapefruit though its actual acidity is less. The flat appearance of the orange curve marks the presence of other salts. The
DETERMINATION OF ACIDITY

The general slanting appearance of the tomato curve is explained by the complexity of its acid constituents.

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\text{\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig120g.png}
\caption{Fig. 120g.}
\end{figure}}
\]

It will be noted of all these titrations that the acids are weak and other salts are plentiful. The abrupt rise at the very beginning of the curve always points to the presence of an undissociated acid. In every case the center of the vertical portion of the curve lies on the alkaline side of the neutrality line. The exact position of this point would be a means of identifying the
acid present, for the weaker the acid the higher is the voltage given by the sodium salt in water. So many acids and other salts are present, however, that the curves show much "buffer action," i.e., they show few sharp flexions and it is not easy to locate the point of equivalence. For the same reason, however, any indicator would give only an arbitrary and empirical value of the equivalence point, and is even less well adapted to showing what is really present.

*The Malic Fruits.*—Fig. 120h represents the malic fruits. Of these the peach is most acid (though this may possibly have been due to the use of an unripe sample in this analysis). The apple and the cherry have the same actual acidity, but are widely different in the total amounts of acid available. The curve for the apple is a simple curve indicating the presence of only one type of acid and few salts. The plum and the cherry curves are extraordinarily flat and hence these fruits are complex in their constitution. The banana, as is well known, is among the least acid of the common fruits.

*The Effect of Ripening.*—Fig. 120i finally shows the effect of ripening in decreasing the fruit acidity. Here Curves 1 and 2 represent juice from two samples of Valencia orange, one of which was kept on ice for a week while the other was kept at room temperature. The marked change in acidity shows an effectual ripening in the second case. Precisely the same is shown by Curves 3 and 4 of this figure, which represents a similar experiment with
two samples of Redlands orange. The peaches represented in Fig. 120h appeared to be ripe but the curve indicates unripeness since this fruit is not usually so acid. Ripeness is thus a factor that needs to be determined before such a curve can be considered representative for any fruit. Finally, this hydrogen electrode method is a useful means of determining ripeness.
APPENDIX.

THE FOOD AND DRUGS ACT, JUNE 30, 1906, AS AMENDED AUGUST 23, 1912
AND MARCH 3, 1913.

AN ACT FOR PREVENTING THE MANUFACTURE, SALE, OR TRANSPORTATION OF ADULTERATED
OR MISBRANDED OR POISONOUS OR DELETERIOUS FOODS, DRUGS, MEDICINES, AND LIQUORS,
AND FOR REGULATING TRAFFIC THEREIN, AND FOR OTHER PURPOSES.

Be it enacted by the Senate and House of Representatives of the United States of America
in Congress assembled, That it shall be unlawful for any person to manufacture within
any Territory or the District of Columbia any article of food or drug which is adulterated
or misbranded, within the meaning of this Act; and any person who shall violate any
of the provisions of this section shall be guilty of a misdemeanor, and for each offense shall,
upon conviction thereof, be fined not to exceed five hundred dollars or shall be sentenced
to one year’s imprisonment, or both such fine and imprisonment, in the discretion of the
court, and for each subsequent offense and conviction thereof shall be fined not less than
one thousand dollars or sentenced to one year’s imprisonment, or both such fine and imprison-
ment, in the discretion of the Court.

Sec. 2. That the introduction into any State or Territory or the District of Columbia
from any other State or Territory or the District of Columbia, or from any foreign coun-
try, or shipment to any foreign country of any article of food or drugs which is adulterated
or misbranded, within the meaning of this Act, is hereby prohibited; and any person who
shall ship or deliver for shipment from any State or Territory or the District of Columbia
to any other State or Territory or the District of Columbia, or to a foreign country, or
who shall receive in any State or Territory or the District of Columbia from any other
State or Territory or the District of Columbia, or foreign country, and having so received,
shall deliver, in original unbroken packages, for pay or otherwise, or offer to deliver to
any other person, any such article so adulterated or misbranded within the meaning of this
Act, or any person who shall sell or offer for sale in the District of Columbia or the Ter-
ritories of the United States any such adulterated or misbranded foods or drugs, or export
or offer to export the same to any foreign country, shall be guilty of a misdemeanor, and
for such offense be fined not exceeding two hundred dollars for the first offense, and upon
conviction for each subsequent offense not exceeding three hundred dollars or be imprisoned
not exceeding one year, or both, in the discretion of the court: Provided, That no article
shall be deemed misbranded or adulterated within the provisions of this Act when Intended
for export to any foreign country and prepared or packed according to the specifications
or directions of the foreign purchaser when no substance is used in the preparation or pack-
ing thereof in conflict with the laws of the foreign country to which said article is intended
to be shipped; but if said article shall be in fact sold or offered for sale for domestic use
or consumption, then this provision shall not exempt said article from the operation of any
of the other provisions of this Act.

Sec. 3. That the Secretary of the Treasury, the Secretary of Agriculture, and the
Secretary of Commerce and Labor shall make uniform rules and regulations for carrying
out the provisions of this act, including the collection and examination of specimens of
foods and drugs manufactured or offered for sale in the District of Columbia, or in any

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Territory of the United States, or which shall be offered for sale in unbroken packages in any State other than that in which they shall have been respectively manufactured or produced, or which shall be received from any foreign country, or intended for shipment to any foreign country, or which may be submitted for examination by the chief health, food, or drug officer of any State, Territory, or the District of Columbia, or at any domestic or foreign port through which such product is offered for interstate commerce, or for export or import between the United States and any foreign port or country.

Sec. 4. That the examinations of specimens of foods and drugs shall be made in the Bureau of Chemistry of the Department of Agriculture, or under the direction and supervision of such Bureau, for the purpose of determining from such examinations whether such articles are adulterated or misbranded within the meaning of this Act; and if it shall appear from any such examination that any of such specimens is adulterated or misbranded within the meaning of this Act, the Secretary of Agriculture shall cause notice thereof to be given to the party from whom such sample was obtained. Any party so notified shall be given an opportunity to be heard, under such rules and regulations as may be prescribed as aforesaid, and if it appears that any of the provisions of this Act have been violated by such party, then the Secretary of Agriculture shall at once certify the facts to the proper United States district attorney, with a copy of the results of the analysis or the examination of such article duly authenticated by the analyst or officer making such examination, under the oath of such officer. After judgment of the court, notice shall be given by publication in such manner as may be prescribed by the rules and regulations aforesaid.

Sec. 5. That it shall be the duty of each district attorney to whom the Secretary of Agriculture shall report any violation of this Act, or to whom any health or food or drug officer or agent of any State, Territory, or the District of Columbia shall present satisfactory evidence of any such violation, to cause appropriate proceedings to be commenced and prosecuted in the proper courts of the United States, without delay, for the enforcement of the penalties as in such case herein provided.

Sec. 6. That the term "drug," as used in this Act, shall include all medicines and preparations recognized in the United States Pharmacopoeia or National Formulary for internal or external use, and any substance or mixture of substances intended to be used for the cure, mitigation, or prevention of disease of either man or other animals. The term "food," as used herein, shall include all articles used for food, drink, confectionery, or condiment by man or other animals, whether simple, mixed, or compound.

Sec. 7. That for the purposes of this Act an article shall be deemed to be adulterated:

In case of drugs:

First. If, when a drug is sold under or by a name recognized in the United States Pharmacopoeia or National Formulary, it differs from the standard of strength, quality, or purity, as determined by the test laid down in the United States Pharmacopoeia or National Formulary official at the time of investigation: Provided, That no drug defined in the United States Pharmacopoeia or National Formulary shall be deemed to be adulterated under this provision if the standard of strength, quality, or purity be plainly stated upon the bottle, box, or other container thereof although the standard may differ from that determined by the test laid down in the United States Pharmacopoeia or National Formulary.

Second. If its strength or purity fall below the professed standard or quality under which it is sold.

In the case of confectionery:

If it contain terra alba, barytes, talc, chrome yellow, or other mineral substance or poisonous color or flavor, or other ingredient deleterious or detrimental to health, or any vinous, malt, or spirituous liquor or compound or narcotic drug.

In the case of food:
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First. If any substance has been mixed and packed with it so as to reduce or lower or injuriously affect its quality or strength.

Second. If any substance has been substituted wholly or in part for the article.

Third. If any valuable constituent of the article has been wholly or in part abstracted.

Fourth. If it be mixed, colored, powdered, coated, or stained in a manner whereby damage or inferiority is concealed.

Fifth. If it contain any added poisonous or other added deleterious ingredient which may render such article injurious to health: Provided, That when in the preparation of food products for shipment they are preserved by any external application applied in such manner that the preservative is necessarily removed mechanically, or by maceration in water, or otherwise, and directions for the removal of said preservative shall be printed on the covering or the package, the provisions of this Act shall be construed as applying only when said products are ready for consumption.

Sixth. If it consists in whole or in part of a filthy, decomposed, or putrid animal or vegetable substance, or any portion of an animal unfit for food, whether manufactured or not, or if it is the product of a diseased animal, or one that has died otherwise than by slaughter.

Sec. 8. That the term "misbranded," as used herein, shall apply to all drugs, or articles of food, or articles which enter into the composition of food, the package or label of which shall bear any statement, design, or device regarding such article, or the ingredients or substances contained therein which shall be false or misleading in any particular, and to any food or drug product which is falsely branded as to the State, Territory, or country in which it is manufactured or produced.

That for the purposes of this Act an article shall also be deemed to be misbranded:

In case of drugs:

First. If it be an imitation of or offered for sale under the name of another article.

Second. If the contents of the package as originally put up shall have been removed, in whole or in part, and other contents shall have been placed in such package, or if the package fail to bear a statement on the label of the quantity or proportion of any alcohol, morphine, opium, cocaine, heroin, alpha or beta eucaine, chloroform, cannabis indica, chloral hydrate, or acetanilide, or any derivative or preparation of any such substances contained therein.

Third. If its package or label shall bear or contain any statement, design, or device regarding the curative or therapeutic effect of such article or any of the ingredients or substances contained therein, which is false and fraudulent.

In the case of food:

First. If it be an imitation of or offered for sale under the distinctive name of another article.

Second. If it be labeled or branded so as to deceive or mislead the purchaser, or purport to be a foreign product when not so, or if the contents of the package as originally put up shall have been removed in whole or in part and other contents shall have been placed in such package, or if it fail to bear a statement on the label of the quantity or proportion of any morphine, opium, cocaine, heroin, alpha or beta eucaine, chloroform, cannabis indica, chloral hydrate, or acetanilide, or any derivative or preparation of any of such substances contained therein.

Third. If in package form, the quantity of the contents be not plainly and conspicuously marked on the outside of the package in terms of weight, measure, or numerical count: Provided, however, That reasonable variations shall be permitted, and tolerances and also exemptions as to small packages shall be established by rules and

* This paragraph constitutes the amendment of August 23, 1912.
† This paragraph is so amended March 3, 1913.
regulations made in account with the provisions of Section three of this Act. That this Act shall take effect and be in force from and after its passage: Provided, however, That no penalty of fine, imprisonment, or confiscation shall be enforced for any violation of its provisions as to domestic products prepared or foreign products imported prior to eighteen months after its passage.

Fourth. If the package containing it or its label shall bear any statement, design, or device regarding the ingredients or the substances contained therein, which statement, design, or device shall be false or misleading in any particular: Provided, That an article of food which does not contain any added poisonous or deleterious ingredients shall not be deemed to be adulterated or misbranded in the following cases:

First. In the case of mixtures or compounds which may be now or from time to time hereafter known as articles of food, under their own distinctive names, and not an imitation of or offered for sale under the distinctive name of another article, if the name be accompanied on the same label or brand with a statement of the place where said article has been manufactured or produced.

Second. In the case of articles labeled, branded, or tagged so as to plainly indicate that they are compounds, imitations, or blends, and the word "compound," "imitation," or "blend," as the case may be, is plainly stated on the package in which it is offered for sale: Provided, That the term blend as used herein shall be construed to mean a mixture of like substances, not excluding harmless coloring or flavoring ingredients used for the purpose of coloring and flavoring only: And provided further, That nothing in this Act shall be construed as requiring or compelling proprietors or manufacturers of proprietary foods which contain no unwholesome added ingredient to disclose their trade formulas, except in so far as the provisions of this Act may require to secure freedom from adulteration or misbranding.

Sec. 9. That no dealer shall be prosecuted under the provisions of this Act when he can establish a guaranty signed by the wholesaler, jobber, manufacturer, or other party residing in the United States, from whom he purchases such articles, to the effect that the same is not adulterated or misbranded within the meaning of this Act, designating it. Said guaranty, to afford protection, shall contain the name and address of the party or parties making the sale of such articles to such dealer, and in such case said party or parties shall be amenable to the prosecutions, fines, and other penalties which would attach, in due course, to the dealer under the provisions of this Act.

Sec. 10. That any article of food, drug, or liquor that is adulterated or misbranded within the meaning of this Act, and is being transported from one State, Territory, District, or insular possession to another for sale, or, having been transported, remains unloaded, unsold, or in original unbroken packages, or if it be sold or offered for sale in the District of Columbia or the Territories, or insular possessions of the United States, or if it be imported from a foreign country for sale, or if it is intended for export to a foreign country, shall be liable to be proceeded against in any district court of the United States within the district where the same is found, and seized for confiscation by a process of libel for condemnation. And if such article is condemned as being adulterated or misbranded, or of a poisonous or deleterious character, within the meaning of this Act, the same shall be disposed of by destruction or sale, as the said court may direct, and the proceeds thereof, if sold, less the legal costs and charges, shall be paid into the Treasury of the United States, but such goods shall not be sold in any jurisdiction contrary to the provisions of this Act or the laws of that jurisdiction: Provided however, That upon the payment of the costs of such libel proceedings and the execution and delivery of a good and sufficient bond to the effect that such articles shall not be sold or otherwise disposed of contrary to the provisions of this Act, or the laws of any State, Territory, District, or insular possession, the court may by order direct that such articles be delivered to the owner thereof. The proceedings of such libel
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CASES SHALL CONFORM, AS NEAR AS MAY BE, TO THE PROCEEDINGS IN ADMIRALTY, EXCEPT THAT EITHER PARTY MAY DEMAND TRIAL BY JURY OF ANY ISSUE OF FACT JOINED IN ANY SUCH CASE, AND ALL SUCH PROCEEDINGS SHALL BE AT THE SUIT OF AND IN THE NAME OF THE UNITED STATES.

SEC. 11. THE SECRETARY OF THE TREASURY SHALL DELIVER TO THE SECRETARY OF AGRICULTURE, UPON HIS REQUEST FROM TIME TO TIME, SAMPLES OF FOODS AND DRUGS WHICH ARE BEING IMPORTED INTO THE UNITED STATES OR OFFERED FOR IMPORT, GIVING NOTICE THEREOF TO THE OWNER OR CONSIGNEE, WHO MAY APPEAR BEFORE THE SECRETARY OF AGRICULTURE, AND HAVE THE RIGHT TO INTRODUCE TESTIMONY, AND IF IT APPEARS FROM THE EXAMINATION OF SUCH SAMPLES THAT ANY ARTICLE OF FOOD OR DRUG OFFERED TO BE IMPORTED INTO THE UNITED STATES IS ADULTERATED OR MISBRANDED WITHIN THE MEANING OF THIS ACT, OR IS OTHERWISE DANGEROUS TO THE HEALTH OF THE PEOPLE OF THE UNITED STATES, OR IS OF A KIND FORBIDDEN ENTRY INTO, OR FORBIDDEN TO BE SOLD OR RESTRICTED IN SALE IN THE COUNTRY IN WHICH IT IS MADE OR FROM WHICH IT IS EXPORTED, OR IS OTHERWISE FALSELY LABELED IN ANY RESPECT, THE SAID ARTICLE SHALL BE REFUSED ADMITTANCE, AND THE SECRETARY OF THE TREASURY SHALL REFUSE DELIVERY TO THE CONSIGNEE AND SHALL CAUSE THE DESTRUCTION OF ANY GOODS REFUSED DELIVERY WHICH SHALL NOT BE EXPORTED BY THE CONSIGNEE WITHIN THREE MONTHS FROM THE DATE OF NOTICE OF SUCH REFUSAL UNDER SUCH REGULATIONS AS THE SECRETARY OF THE TREASURY MAY PRESCRIBE: PROVIDED, THAT THE SECRETARY OF THE TREASURY MAY DELIVER TO THE CONSIGNEE SUCH GOODS PENDING EXAMINATION AND DECISION IN THE MATTER ON EXECUTION OF A PENAL BOND FOR THE AMOUNT OF THE FULL INVOICE VALUE OF SUCH GOODS, TOGETHER WITH THE DUTY THEREON, AND ON REFUSAL TO RETURN SUCH GOODS FOR ANY CAUSE TO THE CUSTODY OF THE SECRETARY OF THE TREASURY, WHEN DEMANDED, FOR THE PURPOSE OF EXCLUDING THEM FROM THE COUNTRY, OR FOR ANY OTHER PURPOSE, SAID CONSIGNEE SHALL FORFEIT THE FULL AMOUNT OF THE BOND: AND PROVIDED FURTHER, THAT ALL CHARGES FOR STORAGE, CARTAGE, AND LABOR ON GOODS WHICH ARE REFUSED ADMITTANCE OR DELIVERY SHALL BE PAID BY THE OWNER OR CONSIGNEE, AND IN DEFAULT OF SUCH PAYMENT SHALL CONSTITUTE A LIEN AGAINST ANY FUTURE IMPORTATION MADE BY SUCH OWNER OR CONSIGNEE.


SEC. 13. THAT THIS ACT SHALL BE IN FORCE AND EFFECT FROM AND AFTER THE FIRST DAY OF JANUARY, NINETEEN HUNDRED AND SEVEN.

THE MEAT-INSPECTION LAW.


That for the purpose of preventing the use in interstate or foreign commerce, as herein-after provided, of meat and meat food products which are unsound, unhealthful, unwholesome, or otherwise unfit for human food, the Secretary of Agriculture, at his discretion, may cause to be made, by inspectors appointed for that purpose, an examination and inspection of all cattle, sheep, swine, and goats before they shall be allowed to enter into any slaughtering, packing, meat-canning, rendering, or similar establishment, in which they are to be slaughtered and the meat and meat food products thereof are to be used in interstate or foreign commerce; and all cattle, swine, sheep, and goats found on such inspection to
show symptoms of disease shall be set apart and slaughtered separately from all other cattle, sheep, swine, or goats, and when so slaughtered the carcasses of said cattle, sheep, swine, or goats shall be subject to a careful examination and inspection, all as provided by the rules and regulations to be prescribed by the Secretary of Agriculture as herein provided for.

That for the purposes hereinbefore set forth the Secretary of Agriculture shall cause to be made by inspectors appointed for that purpose, as hereinafter provided, a post-mortem examination and inspection of the carcasses and parts thereof of all cattle, sheep, swine, and goats to be prepared for human consumption at any slaughtering, meat-canning, salting, packing, rendering, or similar establishment in any State, Territory, or the District of Columbia for transportation or sale as articles of interstate or foreign commerce, and the carcasses and parts thereof of all such animals found to be sound, healthful, wholesome, and fit for human food shall be marked, stamped, tagged, or labeled as "Inspected and Passed;" and said inspectors shall label, mark, stamp, or tag as "Inspected and Condemned," all carcasses and parts thereof of animals found to be unsound, unhealthful, unwholesome, or otherwise unfit for human food; and all carcasses and parts thereof thus inspected and condemned shall be destroyed for food purposes by the said establishment in the presence of an inspector, and the Secretary of Agriculture may remove inspectors from any such establishment which fails to so destroy any such condemned carcass or part thereof, and said inspectors, after said first inspection shall, when they deem it necessary, reinspect said carcasses or parts thereof to determine whether since the first inspection the same have become unsound, unhealthful, unwholesome, or in any way unfit for human food, and if any carcass or any part thereof shall, upon examination and inspection subsequent to the first examination and inspection, be found to be unsound, unhealthful, unwholesome, or otherwise unfit for human food, it shall be destroyed for food purposes by the said establishment in the presence of an inspector, and the Secretary of Agriculture may remove inspectors from any establishment which fails to so destroy any such condemned carcass or part thereof.

The foregoing provisions shall apply to all carcasses or parts of carcasses of cattle, sheep, swine, and goats, or the meat or meat products thereof which may be brought into any slaughtering, meat-canning, salting, packing, rendering, or similar establishment, and such examination and inspection shall be had before the said carcasses or parts thereof shall be allowed to enter into any department wherein the same are to be treated and prepared for meat food products; and the foregoing provisions shall also apply to all such products which, after having been issued from any slaughtering, meat-canning, salting, packing, rendering, or similar establishment, shall be returned to the same or to any similar establishment where such inspection is maintained.

That for the purposes hereinbefore set forth the Secretary of Agriculture shall cause to be made by inspectors appointed for that purpose an examination and inspection of all meat food products prepared for interstate or foreign commerce in any slaughtering, meat-canning, salting, packing, rendering, or similar establishment, and for the purposes of any examination and inspection said inspectors shall have access at all times, by day or night, whether the establishment be operated or not, to every part of said establishment; and said inspectors shall mark, stamp, tag, or label as "Inspected and Passed" all such products found to be sound, healthful, and wholesome, and which contain no dyes, chemicals, preservatives, or ingredients which render such meat or meat food products unsound, unhealthful, unwholesome, or unfit for human food; and said inspectors shall label, mark, stamp, or tag as "Inspected and Condemned" all such products found unsound, unhealthful, and unwholesome, or which contain dyes, chemicals, preservatives, or ingredients which render such meat or meat food products unsound, unhealthful, unwholesome, or unfit for human food, and all such condemned meat food products shall be destroyed for food pur-
poses, as hereinbefore provided, and the Secretary of Agriculture may remove inspectors from any establishment which fails to so destroy such condemned meat food products: Provided, That, subject to the rules and regulations of the Secretary of Agriculture, the provisions hereof in regard to preservatives shall not apply to meat food products for export to any foreign country and which are prepared or packed according to the specifications or directions of the foreign purchaser, when no substance is used in the preparation or packing thereof in conflict with the laws of the foreign country to which said article is to be exported; but if said article shall be in fact sold or offered for sale for domestic use or consumption, then this proviso shall not exempt said article from the operation of all the other provisions of this act.

That when any meat or meat food product prepared for interstate or foreign commerce which has been inspected as hereinbefore provided and marked "Inspected and Passed" shall be placed or packed in any can, pot, tin, canvas, or other receptacle or covering in any establishment where inspection under the provisions of this act is maintained, the person, firm, or corporation preparing said product shall cause a label to be attached to said can, pot, tin, canvas, or other receptacle or covering, under the supervision of an inspector, which label shall state that the contents thereof have been "Inspected and Passed" under the provisions of this act; and no inspection and examination of meat or meat food products deposited or inclosed in cans, tins, pots, canvas, or other receptacle or covering in any establishment where inspection under the provisions of this act is maintained shall be deemed to be complete until such meat or meat food products have been sealed or inclosed in said can, tin, pot, canvas, or other receptacle or covering under the supervision of an inspector, and no such meat or meat food products shall be sold or offered for sale by any person, firm, or corporation in interstate or foreign commerce under any false or deceptive name; but established trade name or names which are usual to such products and which are not false and deceptive and which shall be approved by the Secretary of Agriculture are permitted.

The Secretary of Agriculture shall cause to be made, by experts in sanitation or by other competent inspectors, such inspection of all slaughtering, meat-canning, salting, packing, rendering, or similar establishments in which cattle, sheep, swine, and goats are slaughtered and the meat and meat food products thereof are prepared for interstate or foreign commerce as may be necessary to inform himself concerning the sanitary conditions of the same, and to prescribe the rules and regulations of sanitation under which such establishments shall be maintained; and where the sanitary conditions of any such establishment are such that the meat or meat food products are rendered unclean, unsound, unhealthful, unwholesome, or otherwise unfit for human food, he shall refuse to allow said meat or meat food products to be labeled, marked, stamped, or tagged as "Inspected and Passed."

That the Secretary of Agriculture shall cause an examination and inspection of all cattle, sheep, swine, and goats, and the food products thereof, slaughtered and prepared in the establishments hereinbefore described for the purposes of interstate or foreign commerce to be made during the nighttime as well as during the daytime when the slaughtering of said cattle, sheep, swine, and goats, or the preparation of said food products is conducted during the nighttime.

That on and after October first, nineteen hundred and six, no person, firm, or corporation shall transport or offer for transportation, and no carrier of interstate or foreign commerce shall transport or receive for transportation from one State or Territory or the District of Columbia to any other State or Territory or the District of Columbia, or to any place under the jurisdiction of the United States, or to any foreign country, any carcasses or parts thereof, meat, or meat food products thereof which have not been inspected, examined, and marked as "Inspected and Passed," in accordance with the terms of this act and with the rules and
regulations prescribed by the Secretary of Agriculture: Provided, That all meat and meat food products on hand on October first, nineteen hundred and six, at establishments where inspection has not been maintained, or which have been inspected under existing law, shall be examined and labeled under such rules and regulations as the Secretary of Agriculture shall prescribe, and then shall be allowed to be sold in interstate or foreign commerce.

That no person, firm, or corporation, or officer, agent, or employee thereof, shall forge, counterfeit, simulate, or falsely represent, or shall without proper authority use, fail to use, or detach, or shall knowingly or wrongfully alter, deface, or destroy, or fail to deface or destroy, any of the marks, stamps, tags, labels, or other identification devices provided for in this act, or in and as directed by the rules and regulations prescribed hereunder by the Secretary of Agriculture, on any carcasses, parts of carcasses, or the food product, or containers thereof, subject to the provisions of this act, or any certificate in relation thereto, authorized or required by this act or by the said rules and regulations of the Secretary of Agriculture.

That the Secretary of Agriculture shall cause to be made a careful inspection of all cattle, sheep, swine, and goats intended and offered for export to foreign countries at such times and places, and in such manner as he may deem proper, to ascertain whether such cattle, sheep, swine, and goats are free from disease.

And for this purpose he may appoint inspectors who shall be authorized to give an official certificate clearly stating the condition in which such cattle, sheep, swine, and goats are found.

And no clearance shall be given to any vessel having on board cattle, sheep, swine, or goats for export to a foreign country until the owner or shipper of such cattle, sheep, swine, or goats has a certificate from the inspector herein authorized to be appointed, stating that the said cattle, sheep, swine, or goats are sound and healthy, or unless the Secretary of Agriculture shall have waived the requirement of such certificate for export to the particular country to which such cattle, sheep, swine, or goats are to be exported.

That the Secretary of Agriculture shall also cause to be made a careful inspection of the carcasses and parts thereof of all cattle, sheep, swine, and goats, the meat of which, fresh, salted, canned, corned, packed, cured, or otherwise prepared, is intended and offered for export to any foreign country, at such times and places and in such manner as he may deem proper.

And for this purpose he may appoint inspectors who shall be authorized to give an official certificate stating the condition in which said cattle, sheep, swine, or goats, and the meat thereof, are found.

And no clearance shall be given to any vessel having on board any fresh, salted, canned, corned, or packed beef, mutton, pork, or goat meat, being the meat of animals killed after the passage of this act, or except as hereinbefore provided for export to and sale in a foreign country from any port in the United States. until the owner or shipper thereof shall obtain from an inspector appointed under the provisions of this act a certificate that the said cattle, sheep, swine, and goats were sound and healthy at the time of inspection, and that their meat is sound and wholesome, unless the Secretary of Agriculture shall have waived the requirements of such certificate for the country to which said cattle, sheep, swine and goats or meats are to be exported.

That the inspectors provided for herein shall be authorized to give official certificates of the sound and wholesome condition of the cattle, sheep, swine, and goats, their carcasses and products as herein described, and one copy of every certificate granted under the provisions of this act shall be filed in the Department of Agriculture, another copy shall be delivered to the owner or shipper, and when the cattle, sheep, swine, and goats or their carcasses and products are sent abroad, a third copy shall be delivered to the chief officer of the vessel on which the shipment shall be made.
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That no person, firm, or corporation engaged in the interstate commerce of meat or meat food products shall transport or offer for transportation, sell or offer to sell any such meat or meat food products in any State or Territory or in the District of Columbia or any place under the jurisdiction of the United States, other than in the State or Territory or in the District of Columbia or any place under the jurisdiction of the United States in which the slaughtering, packing, canning, rendering, or other similar establishment owned, leased, operated by said firm, person, or corporation is located unless and until said person, firm, or corporation shall have complied with all the provisions of this act.

That any person, firm, or corporation, or any officer or agent of any such person, firm, or corporation, who shall violate any of the provisions of this act shall be deemed guilty of a misdemeanor, and shall be punished on conviction thereof by a fine of not exceeding ten thousand dollars or imprisonment for a period not more than two years, or by both such fine and imprisonment, in the discretion of the court.

That the Secretary of Agriculture shall appoint from time to time inspectors to make examination and inspection of all cattle, sheep, swine, and goats, the inspection of which is hereby provided for, and of all carcases and parts thereof, and of all meats and meat food products thereof, and of the sanitary conditions of all establishments in which such meat and meat food products hereinbefore described are prepared; and said inspectors shall refuse to stamp, mark, tag, or label any carcase or any part thereof, or meat food product therefrom, prepared in any establishment hereinbefore mentioned, until the same shall have actually been inspected and found to be sound, healthful, wholesome, and fit for human food, and to contain no dyes, chemicals, preservatives, or ingredients which render such meat food product unsound, unhealthful, unwholesome, or unfit for human food; and to have been prepared under proper sanitary conditions, hereinbefore provided for; and shall perform such other duties as are provided by this act and by the rules and regulations to be prescribed by said Secretary of Agriculture; and said Secretary of Agriculture shall, from time to time, make such rules and regulations as are necessary for the efficient execution of the provisions of this act, and all inspections and examinations made under this act shall be such and made in such manner as described in the rules and regulations prescribed by said Secretary of Agriculture not inconsistent with the provisions of this act.

That any person, firm, or corporation, or any agent or employee of any person, firm, or corporation, who shall give, pay, or offer, directly or indirectly, to any inspector, deputy inspector, chief inspector, or any other officer or employee of the United States authorized to perform any of the duties prescribed by this act or by the rules and regulations of the Secretary of Agriculture any money or other thing of value, with intent to influence said inspector, deputy inspector, chief inspector, or other officer or employee of the United States in the discharge of any duty herein provided for, shall be deemed guilty of a felony and, upon conviction thereof, shall be punished by a fine not less than five thousand dollars nor more than ten thousand dollars and by imprisonment not less than one year nor more than three years; and any inspector, deputy inspector, chief inspector, or other officer or employee of the United States authorized to perform any of the duties prescribed by this act who shall accept any money, gift, or other thing of value from any person, firm, or corporation, or officers, agents, or employees thereof, given with intent to influence his official action, or who shall receive or accept from any person, firm, or corporation engaged in interstate or foreign commerce any gift, money, or other thing of value given with any purpose or intent whatsoever, shall be deemed guilty of a felony and shall, upon conviction thereof, be summarily discharged from office and shall be punished by a fine not less than one thousand dollars nor more than ten thousand dollars and by imprisonment not less than one year nor more than three years.

That the provisions of this act requiring inspection to be made by the Secretary of
Agriculture shall not apply to animals slaughtered by any farmer on the farm and sold and transported as interstate or foreign commerce, nor to retail butchers and retail dealers in meat and meat food products, supplying their customers: Provided, That if any person shall sell or offer for sale or transportation for interstate or foreign commerce any meat or meat food products which are diseased, unsound, unhealthful, unwholesome, or otherwise unfit for human food, knowing that such meat food products are intended for human consumption, he shall be guilty of a misdemeanor, and on conviction thereof shall be punished by a fine not exceeding one thousand dollars or by imprisonment for a period of not exceeding one year, or by both such fine and imprisonment: Provided also, That the Secretary of Agriculture is authorized to maintain the inspection in this act provided for at any slaughtering, meat canning, salting, packing, rendering, or similar establishment notwithstanding this exception, and that the persons operating the same may be retail butchers and retail dealers or farmers; and where the Secretary of Agriculture shall establish such inspection then the provisions of this act shall apply notwithstanding this exception.

That there is permanently appropriated, out of any money in the Treasury not otherwise appropriated, the sum of three million dollars, for the expenses of the inspection of cattle, sheep, swine, and goats and the meat and meat food products thereof which enter into interstate or foreign commerce and for all expenses necessary to carry into effect the provisions of this act relating to meat inspection, including rent and the employment of labor in Washington and elsewhere, for each year. And the Secretary of Agriculture shall, in his annual estimates made to Congress, submit a statement in detail, showing the number of persons employed in such inspections and the salary or per diem paid to each, together with the contingent expenses of such inspectors and where they have been and are employed.