The Moisture Content of Tung Fruit from Its Electrical Resistance*

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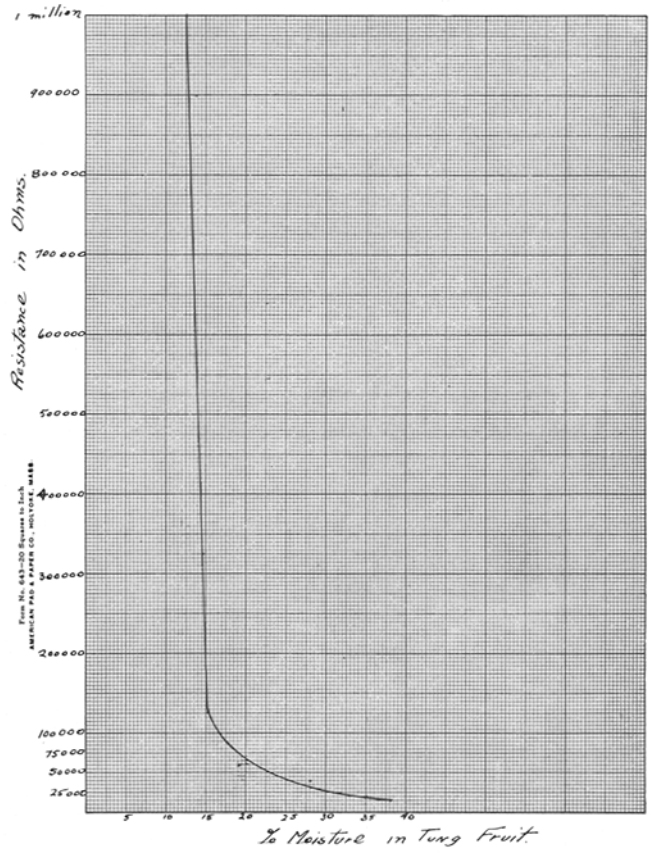
DURING the 1940 tung fruit season it was found that a rapid procedure for determining moisture was needed by the U. S. Tung Oil Laboratories for use in connection with certain drying experiments with tung fruit. It appeared that the tung fruit producers and millers also needed a quick, simple method for determining the moisture content of tung fruit. By this means the producer could ascertain when his fruit is ready for shipment to the mill; also the miller could determine the condition of the fruit for milling purposes and make a fair estimate of his milling costs and yield of tung oil.

Conventional oven methods were not successful, and even when a high temperature and low pressure were used, the time required for the determination was excessive. Experiment showed that moisture can be completely removed from ground tung fruit in ten minutes by passing air at 265° F. through the ground material. However, the operation of grinding the tung fruit may be attended by the loss of appreciable quantities of moisture if the tung fruit is high in moisture.

It has been found that there is a direct relationship between the moisture content of tung fruit and the resistance of the fruit to the passage of a small direct electric current. By means of this relationship, a method has been developed whereby the moisture can be quickly estimated with a fair degree of accuracy. This method is simple and rapid; the apparatus is inexpensive and can be readily carried in the pocket.

The determination of the moisture content of organic material by electrical resistance has been used on various materials for a number of years. Clark (1) in 1926 patented an electrical apparatus for the determination of water in paper and other materials. Since that time electrical apparatus has been used for a similar purpose on the following materials: Traveling webs of material (2), textiles (3), wood (4, 5, 6, 7, 8), bales of cotton (9), corn (10), dried fruits (11), soils (12), wool fiber (13), tea (14), cereals and fruits (15), grains and dairy products (16), dried apples (17), oils and other fuels and paper (19), paper pulp (20), and sand and powdered materials (21).

The various materials whose moisture content has been determined by electrical resistance have been homogeneous. However, in the case of tung fruit, the hull, shell and kernel vary widely, both in composition and in moisture content. The relationship between the moisture content of tung fruit and its electrical resistance undoubtedly is composed of two elements: first, the relationship between the moisture content of the hull and its electrical resistance; and, second, that between the moisture content of the hull and the moisture content of the fruit. If partly dried tung fruits are exposed to rain, the latter relationship is temporarily upset, but after a week the absorbed moisture is redistributed between the component parts of the fruit. Even when the spherical segments of a tung



fruit vary widely in moisture content, a good estimate of the moisture content of the fruit can be obtained by taking readings of the wet and relatively dry segments and then averaging the moisture contents of the segments.

Since perfect equilibrium conditions are not always obtained in the tung fruit under varving storage conditions, there may sometimes be a variation between the estimated and actual moisture content of a tung fruit. However, on a large number of samples it was found that there was less than one percent variation between the average of the estimated and the actual moisture content.

Apparatus

The apparatus consists of a direct-current ohmmeter, reading from 1 ohm to 10 megohms, with lead wires and terminals. The readings are interpreted by reference to a curve which shows the correlation between the resistance of tung fruit and its moisture content.

Procedure

Two parallel holes are bored in a tung fruit, longitudinally one inch apart and one-half inch deep. The two terminals from the ohmmeter are tightly inserted, and, using the maximum amount of internal resistance

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in the ohmmeter, the resistance of the fruit to the passage of the small direct current is read. The moisture content of the tung fruit is estimated from either a table or a curve.

The following table and curve give the correlation between the resistance of a tung fruit in ohms and its moisture content in percent:

Moisture in Percent	Resistance in Ohms
6.3	Infinity
11.2	10 million
11.5	5 million
12.5	1 million
13.7	600,000
14.4	325,000
17.0	105,000
19.3	60,400
27.9	43,000
31.3	24,000
35.0	21,000
37.2	16,000

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Elm Seed Oil II. Studies on Fatty Acid Separation

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THE DETERMINATION of solid and liquid acids, besides its applications to pure research, is of interest technologically for three reasons. These are the determination of saturated acids in oils containing linolenic acids, the determination of the composition of oils or fats having large amounts of unsaponifiable matter, and the determination of solid unsaturated acids in hydrogenated fats.

In the case of fats and oils containing no saturated acids lower than palmitic, nor solid unsaturated acids, the problem of separating solid from liquid acids has been solved by the Twitchell method[9] and its various modifications. Because of the use today of considerable amounts of fats and oils which contain myristic acid and its lower homologs, a method of separating them so that all saturated acids appear in the insoluble fraction would be of value.

Several attempts have been made in the past to solve this problem. Twitchell[7] used petroleum ether as solvent in the separation of the lead salts of lard fatty acids. The iodine numbers of the solid and the liquid acids revealed that the separation was improved by the substitution of this solvent for alcohol and ether. In addition, oxidation of the lead salts of the unsaturated acids, as indicated by the appearance of a yellow color, does not occur in petroleum ether. However, Twitchell found that the solid acids had higher iodine values when the lard fatty acids were not fresh.

Several modifications of the Twitchell lead salt-alcohol method have been proposed to decrease the solubility of the lead salts of the lower acids. The limitations of these methods have been discussed by Stillman and Andrews.[6]

In the course of further studies[5] on elm seed oil, it was found desirable to make a separation of the saturated from the unsaturated acids. The oil, obtained by petroleum ether extraction of seeds produced in the spring of 1937, had the following constants: d 25°/25°, 0.9305; $n^{25°}$, 1.4574, saponification number, 274.6; iodine number, 25.32; thiocyanogen number, 17.18; Reichert-Meissl Number, 2.79; Polenske Number, 34.51; acid number, 1.49; and unsaponifiable matter, 1.45 per cent. By means of ester fractionation the percentage acid composition of the oil used was found to be as follows: caprylic, 4.8; capric, 55.5; lauric, 5.3; myristic, 4.2; palmitic, 2.6; oleic, 10.0; linoleic, 8.1 and linolenic, a trace.

The usual Twitchell method[9] was found to be entirely inapplicable to this oil. It was therefore necessary to search for a combination of salt and solvent which would permit the precipitation of the capric and caprylic acids.

From a consideration of theoretical solubility relations, it is evident that any compound will be most soluble in that solvent to which it is most nearly related in composition and structure. Thus, the unsaturated compounds should be highly soluble in unsaturated solvents, while the corresponding saturated compounds would show a decreased solubility.

A review of the properties of unsaturated liquids reveals that few are suitable with respect to boiling point and to stability toward the reagents required in the separation process. Amylene was deemed to be such a solvent. This substance is available as mixed amylenes, consisting of approximately equal parts of trimethyl ethylene and pentene-2, and as pentene-2 of 90 per cent purity. Both these solvents are water-white liquids of characteristic odor, boiling over a range of approximately 34° to 40°. Portions of these solvents, shaken with a mixture of hydrochloric acid (2 + 1) and lead chloride, showed no change in boiling range or color.

Accordingly, an attempt was made to separate the acids of elm seed oil by means of the lead salts, using as solvents mixed amylenes, pentene-2 and low-boiling petroleum ether. The results obtained follow (Table 1):

TABLE I.

Efficiency of Separation of Lead Salts by Petroleum Ether and Amylenes.

Solvent	Solid Acids Yield Pct.	Solid Acids Iodine No. (Wijs)	Liquid Acids Yield Pct.	Liquid Acids Iodine No. (Wijs)
Petroleum ether	72.68	21.11	11.32	67.90
Mixed amylenes	65.55	9.92	43.44	.....
Pentene-2	68.01	9.58	20.20	67.93

It will be observed, in the case of the two amylenes, that the sum of the solid and liquid acids is greater than the amount of total acids (91.56 per cent) in the original oil. The liquid fraction had a strong odor similar to that of burning oil. On conversion of the liquid acids to soaps and extraction with petroleum