in the manner described could by careful heating be distilled with little or no decomposition.

With the object of extracting the lignoceric acid from the soil if it existed as such, the soil was treated with boiling 95 per cent. alcohol, the extract filtered hot and allowed to cool. On cooling, a voluminous precipitate separated from the dark-colored extract. This was separated by filtration and purified by dissolving several times in hot alcohol from which it separated on cooling and finally by washing with cold petroleum ether. The compound so obtained corresponded in all properties with that obtained by distillation. It melted at 80–81° and elementary analysis gave the following figures:

Calculated for $C_{24}H_{48}O_2$:	C, 78.2; H, 13.0.
Found:	C, 78.2; H, 13.8.

The identity of the two compounds obtained from the soil by distillation and by extraction with hot alcohol is thus established. It follows that lignoceric acid exists in the soil as such.

Regarding the source of the lignoceric acid in the soil there are two possibilities suggested by our knowledge of the compound. It is, as has been already stated, present in peanut oil as a glyceride and may be a component of other vegetable oils and be somewhat widely distributed in plants in small amounts, in which case it might occur in the soil as a residue of the decomposition of such glycerides.

Lignoceric acid is obtained by the distillation of wood, presumably through the decomposition of woody tissue. It is possible that similar decomposition through the agency of microörganisms may take place in the soil.

BUREAU OF SOILS, WASHINGTON, D. C.

[CONTRIBUTION FROM THE LABORATORY OF SOIL FERTILITY INVESTIGATIONS.]

PENTOSANS IN SOILS.[1]

BY EDMUND C. SHOREY AND ELBERT C. LATHROP.

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Carbohydrates, represented by sugars, starch and compound celluloses, make up by far the greater portion of the organic substance of plants and so form the greater portion out of which soil organic matter is made. The extreme susceptibility of these substances to fermentation or decomposition by microörganisms renders them, probably, the most unstable organic material added to soils. Sugars and starch are used by a great variety of bacteria and fungi as food and no doubt disappear as such long before the cell tissues break up and become part of the soil. The cell wall and fibrovascular tissues are made up for the most part of a complex compound containing a carbohydrate or cellulose radical. These resist

[1] Published by permission of the Secretary of Agriculture.

the action of microörganisms longer and in the breaking up of the tissues due to the decay of the least resistant portions, this complex probably gets into the soil to some extent unchanged.

The products of decomposition of such carbohydrates as starch and sugars, are fairly well known and are for the most part simple compounds, such as alcohol, acetic acid and carbon dioxide. The more resistant complexes, the so-called compound celluloses, contain other groups in addition to the carbohydrate radical and can give rise in decay to a great variety of products some of them still quite complex, but resistant to further action of bacteria or fungi. Because of this complexity of the material itself and of its decomposition products, the character of the changes which take place in the decay of this material, either in or out of the soil, is very imperfectly known.

The isolation of carbohydrates from soil is at present confined to a single compound, a pentosan or a substance yielding a pentose sugar.

Nearly all soils when boiled with hydrochloric acid of moderate strength give furfural. The evolution of furfural when an organic mixture is heated with hydrochloric acid is usually regarded as evidence of the presence of pentosans. Pentosans are substances of a gummy nature and unknown constitution for which the formula $C_5H_8O_4$ is usually given; they gives on hydrolysis with acids pentose sugars, $C_5H_{10}O_5$, which are definit crystallin compounds of known constitution. These pentose sugars on further heating with acids give furfural, the amount of furfural being proportional to the amount of pentosan or pentose. Based on this fact a method has been devised for determining the pentosan by determining the amount of furfural obtained under certain conditions. This method is adopted as a provisional one by the Association of Official Agricultural Chemists.[1]

The method, when applied to soils, generally gives weighable quantities of the phloroglucide, the form in which the furfural is determined. The figures given below show results obtained by this method applied to ten soils of widely different types and character of organic matter. Ten grams of soil were used, boiled with 12 per cent. hydrochloric acid and the distillation carried on in the usual manner until there was no further evolution of furfural, which was usually the case when the distillate amounted to 300 or 400 cc. The furfural was determined as phloroglucide and the calculation made according to the formula in the provisional method cited.

The figures given here illustrate well, perhaps better than any others available, the great variation of organic matter in soils. In these ten soils selected somewhat at random the pentosan carbon per 100 of total

[1] Bureau of Chemistry, U. S. Dept. Agr., *Bull.* 107. p. 54. (Revised),

carbon varies from 1.30–28.53, while the third lowest result, 1.83, was obtained from a soil containing the largest quantity of organic matter.

Soil.	Per cent. total carbon.	Per cent. pentosan.	Per cent. pentosan carbon.	Pentosan carbon per 100 of total carbon.
Elkton silt loam	0.522	0.176	0.079	15.13
Sassafras silt loam	0.315	0.055	0.025	7.93
Chester silt loam	1.510	0.182	0.083	5.49
North Carolina peaty soil	27.102	1.090	0.495	1.83
Marshall loam	6.971	2.750	1.249	17.93
California peaty soil	11.478	0.341	0.150	1.30
Norfolk fine sandy loam	0.822	0.027	0.012	1.46
Santa Paula, Cal., loam	1.308	0.061	0.028	2.14
Portsmouth loam	3.854	0.219	0.099	2.57
Susquehanna clay loam	1.048	0.659	0.299	28.53

The Marshall loam containing the largest quantity of pentosan, 2.75 per cent., was selected for further investigation. The soil was from North Dakota and the sample was taken from a field that had grown flax for a number of years. There had been no direct addition of straw or other pentosan-containing material other than that incidental to the growing and harvesting of the crop. An alkaline extract of this soil was made by treating it for several hours with 2 per cent. sodium hydroxide, the dark-colored extract was siphoned off and the humus compounds precipitated by acidifying with acetic acid, the filtrate made neutral and filtered from the precipitate formed. Lead acetate in excess was added to the neutral filtrate, resulting in the formation of a heavy brown precipitate and the removal of nearly all the color from the solution. To the filtrate from this precipitate dilute ammonia was carefully added, when a light yellow, voluminous precipitate was formed. This, after washing, was suspended in water and treated with dilute suphuric acid, avoiding excess. The lead sulphate was removed by filtration and the filtrate concentrated to a small volume. To this solution three volumes of 95 per cent. alcohol were added, when a gummy precipitate was formed which after washing with alcohol dried to a hard, translucent mass. This mass contained traces of lead which it retained very persistently. It was soluble in alkalies and formed an opalescent mucilage with water. On heating with 12 per cent. hydrochloric acid, furfural was given off freely and on heating with phloroglucinol and hydrochloric acid the characteristic purple color reaction for pentose sugars was obtained. On digesting for some time with sulphuric acid of moderate strength and neutralizing, a solution was obtained which reduced Fehling's solution and gave an osazone melting at 160–161°. On treating with cadmium carbonate and bromine according to the method of Bertrand,[1] the characteristic crystals of the double salt cadmium xylonate and cadmium

[1] *Bull. soc. chim.*, [3] 5, 556 (1891).

bromide were obtained, showing the presence of xylose as one of the products of hydrolysis of the substance isolated from the soil. Tests made for the presence of other pentose sugars gave negative results.

The quantitative method of determining pentosan depends as has been noted on the formation of a pentose from the pentosan and the formation of furfural from the sugar on further heating with acid. In the cell wall material which makes up such a large portion of the organic matter of plants no doubt there is a pentosan compound present, either as such, or as part of the complicated molecule of lignocellulose, for a crude pentosan can be prepared from such material. In the case of the Marshall loam such a crude pentosan was obtained and was probably present as such in the soil as a plant residue. In the case of soil organic matter in general, however, it cannot be assumed that the formation of a pentose sugar and from it furfural, necessarily indicates the presence of a pentosan as such. Pentose sugars are part of the complicated molecule of nucleoproteins and phosphatides and are split off from these on heating with acids. The nucleoproteins are characteristic of tissues in which nucleated cells are abundant and those of animal origin have been especially studied. The investigation of those of plant origin is not so thorough, but there is every evidence that the parts of plants rich in cells are also rich in nucleoproteins and this compound and its decomposition products must contribute to the organic matter of the soil.

With this in mind it is evident that a determination of pentosan in soil by the method in general use is simply the determination of the furfural that may arise from a pentosan, a pentose, or a pentose-yielding material other than a pentosan.

In the light of our present knowledge of pentosans and pentose-yielding material, their presence in a soil must be regarded either as a plant residue, such as a portion of the lignocellulose, which has resisted decomposition, or as products of decomposition of complicated compounds such as nucleoproteins.

BUREAU OF SOILS, WASHINGTON, D. C.

[FROM THE LABORATORY OF PHYSIOLOGICAL CHEMISTRY OF THE DEPARTMENT OF ANIMAL HUSBANDRY OF THE UNIVERSITY OF ILLINOIS.]

ON THE PRESERVATION OF FECES.

BY PAUL E. HOWE, T. A. RUTHERFORD AND P. B. HAWK.

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Fresh feces lose nitrogen when subjected to a drying process, even when such process is carried out under the most carefully controlled conditions. Of late years this fact has come to be generally recognized and consequently various schemes have been adopted in the attempt to determin the amount of this lost nitrogen in order that a correcting factor might