

RESEARCH PAPER P1616

*Part of Journal of Research of the National Bureau of Standards, Volume 33,
November 1944*

PREPARATION OF SALTS OF GALACTURONIC ACID FROM BEET PULP

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ABSTRACT

This investigation demonstrates that dried beet pulp can be hydrolyzed by a commercial pectic enzyme, and that calcium galacturonate, sodium calcium galacturonate, and sodium strontium galacturonate can be obtained readily from the hydrolyzate. The crystalline salts are obtained by neutralization of the hydrolyzate with suitable bases, followed by concentration. Samples of dried beet pulp gave calcium galacturonate, sodium calcium galacturonate, and sodium strontium galacturonate in yields corresponding to 105 g, 227 g, and 255 g/kg, respectively.

It is also shown that sodium strontium galacturonate can be separated, at least in some cases, directly from silage drainage liquor. The occurrence of galacturonic acid in the drainage liquor suggests the possibility of developing a process in which hydrolysis is effected by organisms grown in beet pulp.

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I. INTRODUCTION

In connection with the development of a process for the synthesis of vitamin C [1],¹ a cheap source of galacturonic acid was needed. In 1932 Ehrlich found that the polygalacturonide, now known as pectic acid, a product of the hydrolysis of the original pectic substances of plants, when treated with an enzyme prepared from a "*Penicillium ehrlichii*," gives galacturonic acid in high yield [2]. Even prior to that time, Willaman and Kertesz had developed a method and enzyme for effecting the hydrolysis of pectic substances in fruit juices [3]. Shortly thereafter a pectic enzyme preparation, presumably the same as that of Willaman and Kertesz, was produced by Rohm and Haas and sold under the trade name of "Pectinol." A process developed by Mottern and Cole [4] involved treating pectic acid with Pectinol and extracting galacturonic acid from the hydrolyzate with ethyl alcohol. Pigman [5] improved the process by the use of methyl alcohol instead of ethyl alcohol. Although the method is fairly simple, it is nevertheless expensive because of the cost of the pectic acid and of the alcohol required in separating the galacturonic acid from the accompanying impurities. A study was therefore made of the salts of galacturonic acid with the object of finding a salt of relatively low solubility, which would be suitable for the separation of the acid [6]. In the course of the work 12 new crystalline salts were prepared. Several of these, especially sodium strontium galacturonate, sodium calcium galacturonate,² and calcium galacturonate were found to be useful for the separation of galacturonic acid from solutions containing substantial amounts of impurities. The way was thus opened for the preparation of galacturonic acid from the hydrolyzates of plant materials by separating the acid as a difficultly soluble salt. It has been known for some time that the pulp remaining after the separation of sugar from sugar beets, contains substantial quantities of pectic substances, which can be hydrolyzed to yield arabinose, galactose, methyl alcohol, acetic acid, and galacturonic acid [7]. Hence beet pulp provides a vast potential source of galacturonic acid. The application of the new salts to the separation of galacturonic acid from hydrolyzates of beet pulp is the subject of the present paper. In a separate publication [8] the use of sodium strontium galacturonate for the preparation of galacturonic acid from citrus pectic acid, pectin, and the residues of the citrus fruit industry is reported.

II. ENZYMATIC HYDROLYSIS OF DRIED BEET PULP

There are at least three types of enzymes involved in the hydrolysis of pectic substances: protopectinase, pectase, and pectinase [9]. Protopectinase causes the formation of soluble pectins from protopectin, the original pectic substance; pectase removes the methoxyl groups from soluble pectins, leaving pectic acid, which in the presence of calcium or other alkaline earth salts forms gels; pectinase causes hydrolysis of the glycosidic linkages in pectins and pectic acid, with the formation of galacturonic acid, arabinose, galactose, and other simple substances. Ehrlich discovered a mold growing on sugar beets, *Penicillium ehrlichii*, and used it for the preparation of an enzyme which causes complete hydrolysis of

¹ Figures in brackets indicate the literature references at the end of this paper.

² This salt was prepared independently by R. Pasternack and P. P. Regna. See U. S. Patent 2,338,534 (1944).

pectic acid [2]. He also obtained an active protopectinase preparation from *Penicillium glaucum*, and showed that in small quantity it causes extensive dissolution of beet pulp [10]; he did not report the composition of the resulting hydrolyzate.

The availability of a commercial pectic enzyme, and of the difficultly soluble salts of galacturonic acid, led to our attempt to prepare galacturonic acid directly from beet pulp. It was known that Pectinol causes complete hydrolysis of pectic acid [4] and of soluble pectins [11], but it was not known whether it would attack the protopectin in the cell walls of the beet root.

When dried beet pulp³ in water suspension was treated with Pectinol, a large portion of the pulp liquefied within the first 2 days, and the mixture became strongly acid. In our early experiments, the acidity was adjusted at the beginning to pH 3.7, approximately the optimum point for the hydrolysis of pectic acid by the enzyme. It was found, however, that the acidity of the beet pulp-Pectinol mixture soon approached the optimum point without the addition of acid, and hence the preliminary acid treatment was discontinued. The increase in acidity may be ascribed to the presence of an esterase in the enzyme preparation. The conversion of over 65 percent of the dried pulp to soluble solids shows that Pectinol contains an enzyme (protopectinase) that attacks the original pectic substances of the beet root. The amount of hydrolysis depends to some extent upon the amount of the enzyme used, but there is no direct proportion. Thus 46 percent of the pulp was converted to soluble solids in 2 weeks by the action of 5 g of Pectinol per kilogram of beet pulp, whereas 66 percent of the pulp was converted by the action of 100 g of Pectinol. Because of the heterogeneous character of the beet pulp-Pectinol mixture, calculation of the velocity constants was not attempted. A few curves, however, are given in figure 1 to show some of the changes that take place during the hydrolysis. In other experiments the hydrolyzate was analyzed, and the galacturonic acid was separated in the form of the calcium, sodium calcium, or sodium strontium salt. These substances were prepared under strictly comparable conditions in order to ascertain their relative merits for the separation of galacturonic acid. The results show that sodium strontium galacturonate crystallizes from hydrolyzates of beet pulp in the highest yield, but all three salts have value for the separation of galacturonic acid from the hydrolyzates of pectic substances. Sodium strontium galacturonate was obtained in the amount of 250 g/kilogram of dried beet pulp.

In addition to galacturonic acid, the beet pulp hydrolyzate contained substantial quantities of acetic acid and L-arabinose. In a commercial process the acetic acid might be reclaimed by distillation and the L-arabinose might be separated from the mother liquor obtained after crystallization of the galacturonate. The feasibility of separating L-arabinose was shown by the preparation of the crystalline sugar from the liquor in yield corresponding to 62 g/kg of dried pulp (see p. 397). It is of interest to note in this connection that L-arabinose was originally prepared from beet pulp, and that this

³ Dried beet pulp was studied because the work was conducted at some distance from the source of supply, and at periods when the fresh pulp was not available. On account of the high temperatures employed in the drying process, some changes may have taken place in the pectic substances originally in the pulp. For this reason, the behavior of dried pulp may not be strictly comparable to that of fresh pulp. In a commercial process, fresh pulp could be employed, with a preliminary heat treatment to facilitate dissolution, and destroy objectionable micro-organisms.

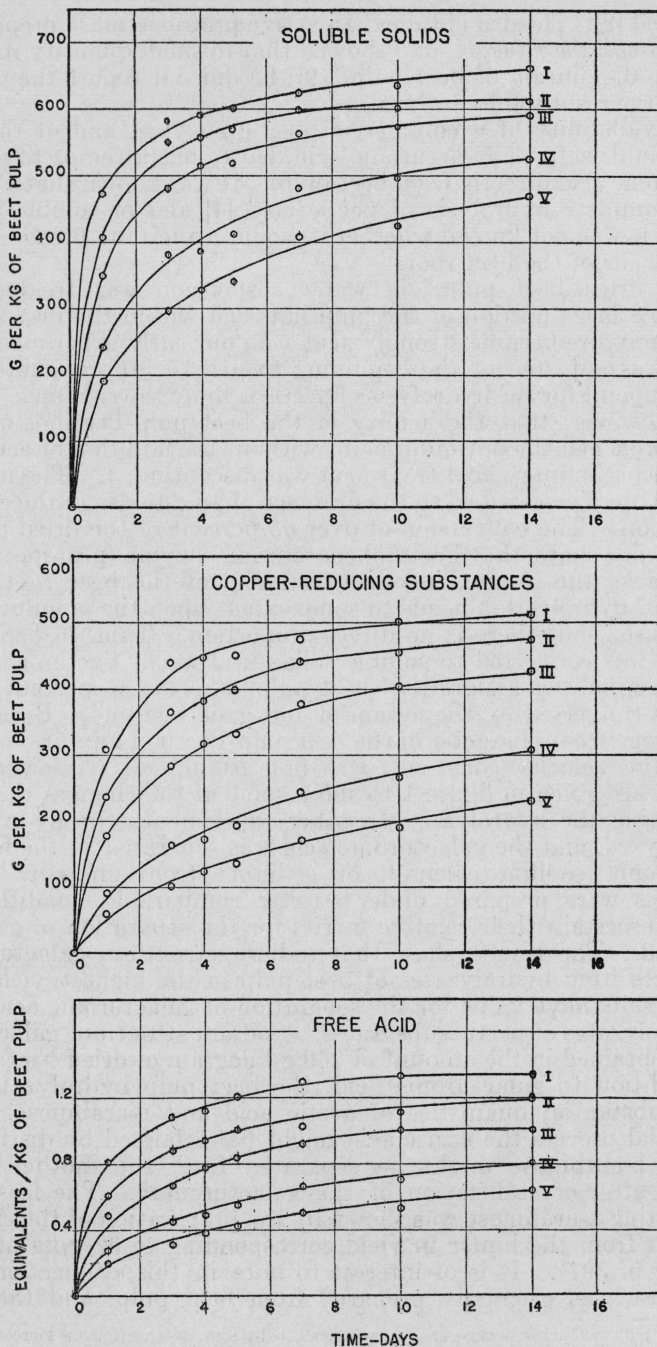


FIGURE 1.—Analytical data for hydrolyzates from beet pulp treated with various quantities of a pectic enzyme.

I. 5.0 g of Pectinol plus 50 g of pulp plus 500 ml of water at 35° C. II. 2.5 g of Pectinol plus 50 g of pulp plus 500 ml of water at 35° C. III. 1.5 g of Pectinol plus 50 g of pulp plus 500 ml of water at 35° C. IV. 0.5 g of Pectinol plus 50 g of pulp plus 500 ml of water at 35° C. V. 0.25 g of Pectinol plus 50 g of pulp plus 500 ml of water at 35° C.

material is still considered to be one of the best sources of arabinose [12].

III. ENZYMATIC HYDROLYSIS OF BEET PULP DURING THE SILOING PROCESS

During the storage of beet pulp in silos, there sometimes occurs considerable liquefaction of the pulp; this condition has been observed frequently in certain districts, in others rarely. It seemed possible that the liquefaction of the pulp in the silos might have been caused by enzymes generated by micro-organisms similar to the mold isolated by Ehrlich, and that silage drainage liquor might provide a source of galacturonic acid. An analysis of a sample of silage drainage liquor, p. 399, showed the presence of substantial quantities of galacturonic acid and arabinose. However, the low copper-reduction value of the silage drainage liquor indicates that a considerable part of the galacturonic acid and arabinose was not in the free state, and hence it appears that hydrolysis of the original pectic substance was only partially complete. Presumably the liquor contained soluble pectins and pentosans, together with free galacturonic acid. Neutralization of the liquor with a mixture of sodium bicarbonate and strontium carbonate in equimolecular proportions gave a solution which, on concentration, yielded crystalline sodium strontium galacturonate. The occurrence of galacturonic acid in the silage drainage liquor is noteworthy because the organisms in the silo might have utilized the galacturonic acid to form lower acids and other degradation products. Undoubtedly, under more favorable conditions, the hydrolysis in the silo could be effected more completely and with larger yields of galacturonic acid.

IV. POSSIBLE SOURCES OF PECTIC ENZYMES

These studies suggest the possibility of developing a method for obtaining galacturonic acid from pectic substances by inoculating fresh beet pulp with organisms known to yield protopectinase and pectinase. The enzyme could be brought in contact with the pulp by percolation of water through the mold growth which forms on top of the silo. However, a batch process, such as that used in the malting of grain, might prove more practicable.

Since pectic enzymes are produced in the growth of numerous molds, and occur in the culture media, it seems possible that the enzymes could be obtained economically as byproducts of certain industries. Possible sources are the aqueous solution remaining after the separation of penicillin, or the culture media of molds grown for food purposes.

V. USE OF PECTIC ENZYMES FOR ANALYTICAL PURPOSES

The material made soluble by treatment of plant products with pectic enzymes constitutes an important group of carbohydrates markedly different from crude fiber, sugar, or starch. The extensive liquefaction of beet pulp observed in this investigation suggests the use of enzymatic degradation in the analysis of feeds and food products. For convenience, material made soluble by a definite treatment with a pectic enzyme preparation could be designated as "pectic enzyme-soluble

substances." Thus an analysis of dried beet pulp might include moisture, fat, protein, crude fiber, ash, and pectic enzyme-soluble substances. The determination of the pectic enzyme-soluble fraction is suggested in place of the fraction ordinarily designated "nitrogen-free extract," since the latter is open to serious objection. (See p. 10 of [13].) The determination of the pectic-enzyme soluble fractions of representative samples of the more common vegetables and fruits would constitute a worthwhile project.

VI. EXPERIMENTAL DETAILS

1. MATERIALS

The dried beet pulp used was kindly supplied by the Great Western Sugar Co. Most of the work was conducted on a sample of dried pulp from Bayard, Nebr., the label of which carried the following data:

Crude protein, not less than	7.0%
Crude fat, not less than	0.3%
Crude fiber, not more than	22.5%
Nitrogen-free extract, not less than	48.0%
(composed only of residue of sugar beets dried after extraction of sugar).	

Before use, the pulp was extracted with water in a conical percolator until the wash water gave no test for sugar. The pulp was then air-dried for a period of several weeks, after which time it gave the following analytical data:

Moisture	8.21%
Ash	2.77%
Galacturonic acid, (CO ₂ method)	26.0%
Arabinose	22.2%

The silage drainage, likewise supplied by the Great Western Sugar Co., was obtained from a silo showing excessive loss due to liquefaction. The sample was taken at Loveland, Colo., in February 1943. It was protected from mold growth by the addition of toluene and stored in a refrigerator until analyzed.

The enzyme used here, Pectinol-46AP, was purchased from Rohm and Haas, Philadelphia, Pa. It had been standardized by the manufacturer to an activity arbitrarily designated 100D.

2. ANALYTICAL METHODS

(a) SOLIDS

The total solids in the hydrolyzate were determined by drying a 5-ml sample on pure quartz sand to constant weight in a vacuum oven at 60° C and a pressure of approximately 5 mm. A higher temperature was not used because of the instability of galacturonic acid.

(b) VOLATILE ACIDS

Volatile acids were determined by steam [distillation, and titration of the distillate with standard alkali, as described on p. 167 of [14].

(c) COPPER-REDUCING SUBSTANCES

The copper-reduction values were determined on neutralized samples of the hydrolyzate by a modified Scales method [15]. Be-

cause of the slowness with which galacturonic acid reacts, it was necessary to increase the boiling time to 10 minutes. Factors were determined for a mixture of galacturonic acid and arabinose in the proportion in which they were found in the hydrolyzate. Presumably the solutions contained galactose in addition to galacturonic acid and arabinose; the galactose factor, however, does not differ widely from the factor (1.25 mg/ml of 0.04 *N* iodine) determined for the mixtures. Hence, the value 1.25 was used in estimating the quantity of reducing substances.

(d) GALACTURONIC ACID

The substance was determined by the method of Lefèvre and Tollens [16], essentially as described by Ehrlich, p. 1661 of [7].

(e) FURFURAL

The determination was made by the procedure described on p. 362 of [14].

(f) ARABINOSE

The amount of arabinose in the hydrolyzate was calculated by the method of Ehrlich and Schubert [17]. Both galacturonic acid and arabinose yield furfural when heated with 12-percent hydrochloric acid. By subtracting the amount of furfural phloroglucide equivalent to the galacturonic acid (weight of galacturonic acid divided by 2.64) from the weight of phloroglucide found, the amount of phloroglucide produced from the arabinose was ascertained; by use of Kröber's table (p. 686 of [14]) the corresponding weight of arabinose was found. To establish the identity of the pentose responsible for the production of furfural, crystalline L-arabinose was separated from the hydrolyzates as described on p. 397.

(g) GALACTOSE

The difference between the copper-reducing substances and the sum of galacturonic acid and arabinose was taken to be galactose, a substance which Ehrlich and Sommerfeld reported to be a constituent of the pectic acid prepared from beet pulp [18].

3. INVESTIGATION OF DRIED BEET PULP

(a) EFFECT OF CONCENTRATION OF ENZYME

In order to ascertain the quantity of enzyme required to effect satisfactory hydrolysis of dried beet pulp, samples of the pulp were treated with various quantities of Pectinol, and the amount of hydrolysis was followed by the determination of soluble solids, reducing sugar, and free acid. Each hydrolysis mixture was prepared by the addition of Pectinol to 50 g of beet pulp in 500 ml of water contained in a 1-liter glass-stoppered Erlenmeyer flask. Mold growth was inhibited by the addition of 10 ml of toluene, and the flasks were maintained at a temperature of 35° C for 2 weeks. From time to time representative samples of the reaction mixtures were withdrawn and soluble solids, copper-reducing substances, and free acid were determined on the filtered hydrolyzates. The results are shown in figure 1. The curves reveal that even with large quantities of the enzyme, hydrolytic reactions take place over a period of at least 2 weeks and that the extent of hydrolysis increases with increasing

amounts of enzyme. Because of the heterogeneous nature of the beet pulp-enzyme mixture and the complex character of the reactions, a quantitative interpretation of the data has not been included. Measurements were not made with mixtures containing more than 1 part of enzyme to 10 parts of beet pulp.

(b) PROPERTIES AND COMPOSITION OF THE HYDROLYZATE

To study the properties and composition of the hydrolyzate more closely, a mixture of 1 kg of dried beet pulp, 100 g of Pectinol, 10 liters of water, and 100 ml of toluene was allowed to stand at 35° C, with occasional stirring. After 10 days, the mixture was filtered through a Büchner funnel and the material on the funnel was washed with hot water and dried. It weighed 378 g, which, after allowance for the insoluble portion of the Pectinol (63 g), gave a weight of 315 g for the insoluble residue of the beet pulp. The filtrate and washings were combined and used for analysis (table 1). The sum of moisture in the original pulp (82 g), insoluble residue of the hydrolyzate (315 g), and soluble solids in the hydrolyzate (560 g) is only 957 g. The difference from the weight of the original pulp is 43 g, presumably volatile substances such as acetic acid and methyl alcohol. The volatile acid actually determined was 0.60 equivalent, or, expressed as acetic acid, 36 g.

TABLE 1.—*Analysis of the filtered hydrolyzate*^a

Optical rotation, °S in a 2-dm tube	*23.6
Refractive index, N_D^{20}	*1.3427
Acidity, pH	*3.4
Soluble solids	560 g
Ash	32.2 g
Ca	4.86 g
Mg	3.15 g
Volatile acid	0.60 equivalent
Free acid	1.05 equivalent
Copper-reducing substances (modified Scales method)	488 g
Galacturonic acid (CO ₂ method)	236 g
Arabinose ^b (furfural method)	214 g
Galactose (by difference)	38 g

^aAll values, except those marked with the asterisk, are based on the total hydrolyzate from 1 kg of air-dried beet pulp containing 8.2 percent of moisture. The volume of the hydrolyzate and wash liquor was 21.7 liters.

^bA sample of the hydrolyzate corresponding to 1 g of beet pulp gave 0.2783 g of furfural phloroglucide by the method of p. 362 of [14]. Presumably, 0.0894 g of the phloroglucide was derived from the galacturonic acid. The remainder, 0.1889 g corresponds to 0.214 g of arabinose or to 0.172 g of pentosans.

(c) SEPARATION OF CARBOHYDRATE CONSTITUENTS FROM THE HYDROLYZATE

One kilogram of dried beet pulp was treated with 100 g of Pectinol in 10 liters of water in the manner previously described. The analyses of the filtered hydrolyzate showed the presence of 220 g of galacturonic acid and of 1.16 equivalents of free acid. The liquor was divided into portions, from which were prepared sodium calcium galacturonate, sodium strontium galacturonate, and calcium galacturonate, respectively. The mother liquor from the preparation of sodium strontium galacturonate was used for the preparation of arabinose.

(1) *Sodium calcium galacturonate*.—One-third of the hydrolyzate described above was digested with 12.8 g of calcium carbonate at 70° C. When reaction was complete, 10.8 g of sodium bicarbonate was added, and the solution was filtered and evaporated under reduced pressure to a volume of 500 ml. The solution was seeded with crystalline sodium calcium galacturonate and allowed to stand in a refrigerator until crystallization was complete. The resulting crystals were collected on a filter, washed with a little cold water, and dried. The product weighed 68.5 g and was substantially pure sodium calcium galacturonate. The mother liquor was saturated with ethyl alcohol, and after 1 day, the resulting crystals (7.0 g) were separated. The yield of sodium calcium galacturonate in the first crop was 20.6 percent of the weight of the dry beet pulp, or 72.5 percent of the salt theoretically obtainable from the galacturonic acid in the hydrolyzate. The total yield (75.5 g) which was 22.7 percent of the weight of the pulp, corresponds to 79.9 percent of the galacturonate acid in the hydrolyzate.

(2) *Sodium strontium galacturonate*.—This substance was prepared from one-third of the hydrolyzate in the same manner as sodium calcium galacturonate, except that 18.8 g of strontium carbonate was used in place of the calcium carbonate. The crop of crystals obtained directly from the aqueous solution weighed 77.7 g; a second crop obtained from the mother liquor by the addition of 50 ml of 95-percent ethyl alcohol weighed 7.2 g. The yield from aqueous solution was 23.3 percent of the dry pulp, corresponding to 77.3 percent of the galacturonic acid in the hydrolyzate. The total yield of sodium strontium galacturonate (84.9 g) was 25.5 percent of the pulp, corresponding to 84.5 percent of the galacturonic acid in the hydrolyzate. The mother liquor that remained after crystallization of the salt was used for the preparation of L-arabinose.

(3) *Calcium galacturonate*.—The remaining third of the hydrolyzate was digested at 70° C with 19.1 g of calcium carbonate until reaction was complete, and the solution was concentrated under reduced pressure to a volume of 500 ml. It was seeded with crystalline calcium galacturonate and allowed to stand in a refrigerator until crystallization was complete. The crystals of calcium galacturonate, when separated and air-dried, weighed 25 g. A second crop of 10 g was obtained by saturation of the mother liquor with ethyl alcohol. The yield of calcium galacturonate in the first crop was 7.5 percent of the weight of the dry beet pulp and corresponds to 29.8 percent of the salt theoretically obtainable from the galacturonic acid in the hydrolyzate. The total yield of the salt was 10.5 percent of the weight of the pulp, and corresponds to 41.7 percent of the galacturonic acid in the hydrolyzate.

(4) *L-Arabinose*.—Although beet pulp has been used for the preparation of arabinose [12], higher yields are obtained from cherry gum [19] or from mesquite gum [20]. The process described here for the preparation of galacturonic acid from beet pulp hydrolyzates yields sirupy residues suitable for the preparation of arabinose. The arabinose may be separated by essentially the same method as that previously used for the separation of arabinose from the hydrolyzates of cherry gum or of mesquite gum.

The mother liquor from the preparation of sodium strontium galacturonate was evaporated under reduced pressure to a thick sirup. This was extracted with three 500-ml portions of hot 95-percent ethyl alcohol. The combined extracts were cooled to room temperature and filtered after the addition of 25 g of a decolorizing carbon. The alcoholic solution was evaporated to 150 ml, diluted with 50 ml of glacial acetic acid, and seeded with crystalline L-arabinose. After 3 days, the crystals, which formed, were collected on a filter, washed with 30 ml of acetic acid in four portions, and dried. The crystalline arabinose so obtained weighed 22.0 g and gave an equilibrium specific rotation of $+98.4^\circ$. Since pure L-arabinose has an equilibrium specific rotation of $+104^\circ$, the purity of the crude product is 94.6 percent, and the yield of pure arabinose corresponds to 62.4 g/kg of dried beet pulp, or 29 percent of the amount in the hydrolyzate. The low yield suggests that part of the arabinose was present as arabans.

4. INVESTIGATION OF SILAGE DRAINAGE LIQUOR

From the analysis of the silage drainage liquor reported in table 2, it will be noted that the liquor gave carbon dioxide equivalent to 10.7 g of galacturonic acid per liter and furfural equivalent to 11.5 g of arabinose, or 9.2 g of pentosans. The copper-reducing substances, however, were only 6.1 g per liter. These results indicate that the galacturonic acid is present in part in the form of soluble pectins and the arabinose in the form of arabans. The presence of some free galacturonic acid was shown by the separation of crystalline sodium strontium galacturonate in the following manner:

Eighteen liters of the liquor was digested with 50 g of strontium carbonate at 70° C. When reaction was complete, 30 g of sodium bicarbonate was added. The mixture was filtered with the aid of a decolorizing carbon, and the filtrate was concentrated in a vacuum still to a volume of 1 liter. The solution was seeded with crystalline sodium strontium galacturonate and allowed to stand in the refrigerator for several days. The crystals, which separated, were collected on a filter, washed with a small quantity of water, and finally dried. The product weighed 31 g, and a second crop of 6.8 g was obtained by the addition of alcohol to the mother liquor. The crude salt was recrystallized twice from hot water and identified as sodium strontium galacturonate by its optical rotation and by a mixed solubility determination with authentic sodium strontium galacturonate. The yield of sodium strontium galacturonate from the silage drainage corresponds to 14.3 percent of the galacturonic acid found by analysis. Although the yield is low, the separation of the crystalline salt from the silage drainage, without involved purification steps, demonstrates the possibility of obtaining galacturonic acid from beet pulp through the action of enzymes produced by organisms grown on the pulp.

TABLE 2.—Analysis of silage drainage liquor

Refractive index, N_D^{20} -----	1.3380.
Acidity, pH-----	3.5.
Soluble solids-----	31.2 g/liter.
Ash-----	1.9 g/liter.
Volatile acid-----	0.153 equivalent per liter.
Free acid-----	0.173 equivalent per liter.
Copper-reducing substances-----	6.1 g/liter.
Galacturonic acid-----	10.7 g/liter.
Pentosans ^a -----	9.2 g/liter.

^a A 10-milliter sample of the silage drainage gave 0.1391 g of furfural phloroglucide, of which 0.0405 g was presumably derived from the galacturonic acid. The remainder corresponds to 0.115 g of arabinose or to 0.092 g of pentosans.

VII. SUMMARY

Treatment of certain samples of dried beet pulp with a commercial pectic enzyme caused hydrolysis of the original pectic substances, and the dissolution of about 65 percent of the dry substance. The hydrolyzate from 1 kg of dried pulp contained approximately 236 g of galacturonic acid, 214 g of arabinose, 38 g of galactose, and 36 g of acetic acid. The galacturonic acid in the hydrolyzate was separated as calcium galacturonate in 42-percent yield, as sodium calcium galacturonate in 80-percent yield, and as sodium strontium galacturonate in 85-percent yield. The mother liquor from the preparation of sodium strontium galacturonate gave L-arabinose in 29-percent yield. Because of exceptionally good crystallizing properties, sodium strontium galacturonate appears to be the most suitable salt for the separation of galacturonic acid from the hydrolyzates of plant materials.

It was found that the drainage liquor from a beet pulp silo in which there had been excessive liquefaction contained approximately 10 g of galacturonic acid per liter and that part of this material could be reclaimed in the form of sodium strontium galacturonate without the use of a commercial enzyme. The separation of a salt of galacturonic acid from the drainage liquor suggests the possibility of developing a process in which hydrolysis is effected by organisms grown in the moist beet pulp. It is also suggested that the aqueous solutions which remain after the separation of penicillin, or the culture media of molds grown for food purposes may ultimately provide a source of pectic enzymes for use in the preparation of galacturonic acid from beet pulp or other pectic substances.

The authors express their appreciation to S. J. Osborn, of the Great Western Sugar Co., for his cooperation in providing the samples of beet pulp and silage drainage liquor used in the investigation, and to Nancy Holt, of this Bureau, for her assistance in the analytical work.

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WASHINGTON, August 25, 1944.