[CONTRIBUTION FROM THE DEPT. OF CHEMISTRY, DACCA UNIVERSITY]

CORCHSULARIN, A NEW BITTER FROM JUTE SEEDS. I. ITS ISOLATION AND CONSTITUTION OF CORCHSULAROSE

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Tsuno (1) first reported isolation of corchorin, a crude amorphous bitter stuff from aqueous extract of jute seeds (*Corchorus capsularis*, Linn.). Sen (2–8) thoroughly studied the chemical composition of jute seeds (*Corchorus capsularis* as well as *Corchorus olitorius*) and succeeded in isolating the crystalline bitters, corchorin, $C_{22}H_{36}O_8$, m.p. 174–175° (4) and corchoritin, $C_{12}H_{18}O_3$, m.p. 218–220° (5) from the alcoholic extract of jute seeds. According to Sen (4), corchorin is a glucoside with $\Delta^{\beta,\gamma}$ unsaturated lactone group and possesses pharmacological properties like members of the digitalis group (8). Soliman and Saleh (9) identified corchorin as strophanthidin. Chaudhury and Dutta (10) also isolated corchorin from the seeds of *Corchorus capsularis*. Karrer and Banerjee (11) isolated corchortoxin, $C_{23}H_{32}O_6$, m.p. 247°, another cardiac agent from jute seeds. Saha and Chaudhury (12) isolated a bitter glycoside, capsularin, $C_{22}H_{36}O_8$, m.p. 175–176° from the leaves of *Corchorus capsularis*. Another new bitter, corchsularin (13) has been isolated from the alcoholic extract of jute seeds and this paper is devoted to its study.

Two varieties of jute plants—*Corchorus capsularis*, Linn. and *Corchorus olitorius*, Linn.—are grown in Bengal (Pakistan) and corchsularin is present in both varieties. It crystallizes from methanol in thin colorless needles and melts at 158° (dec). It has $[\alpha]_D^{25}$ 48.98° in methanol. From analytical data its molecular formula is $C_{30}H_{52}O_7 \cdot 2H_2O$. It may be mentioned here that in the previous report (13) its molecular formula was given as $C_{30}H_{57}O_9$ but later work lends support to $C_{30}H_{56}O_9$. It forms a crystalline diacetate, m.p. 221–223° (dec).

Corchsularin, on hydrolysis in alcoholic hydrochloric acid, gives a mole of sugar, corchsularose $C_6H_{12}O_4$, and a genin, corchsugenin $C_{24}H_{40}O_3$.

$$C_{30}H_{52}O_7 + H_2O \rightarrow C_6H_{12}O_4 + C_{24}H_{42}O_4$$

$$C_{24}H_{42}O_4 - H_2O \rightarrow C_{24}H_{40}O_3$$

It appears that during the process of hydrolysis there has been a simultaneous addition and elimination of a mole of water.

Corchsularose gives a positive Molisch's test for carbohydrate, reduces Fehling's and Benedict's solution, decolorizes alkaline methylene blue, restores the color of the Schiff's reagent, responds to the Keller-Kiliani test (14), gives a blue Dische color (15), and also produces a yellow color with a green fluorescence in the Doebner-Miller reaction (16). The aldose nature of corchsularose is indicated by the easy reduction of Fehling's and Benedict's solutions and also by decolorization of an alkaline methylene blue solution and restoration of the color of the

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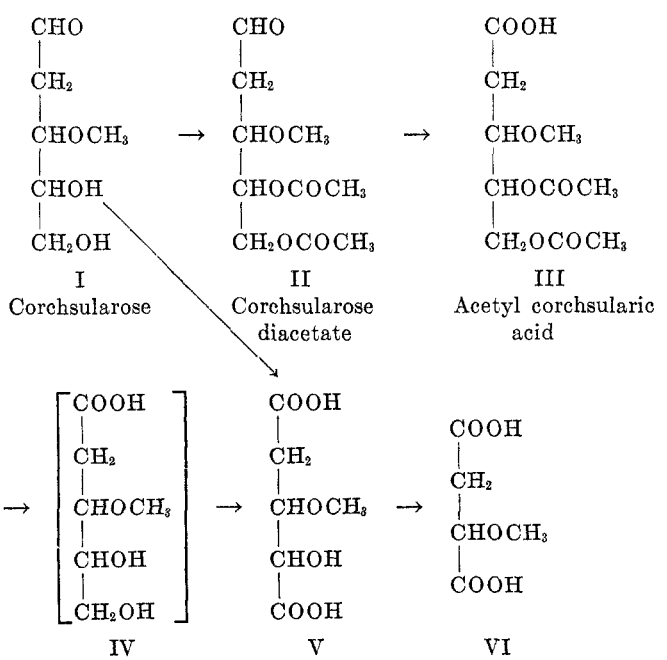
Schiff's reagent. The Keller-Kiliani test and the formation of blue Dische color indicate the 2-desoxy nature of the sugar. Color production in the Doebner-Miller reaction points to the presence of a —CH_2CHO group in the sugar molecule.

Corchsularose forms dibenzoate, $C_{20}H_{20}O_6$ and diacetate $C_{10}H_{16}O_6$, which, eventually, shows the presence of two hydroxyl groups. It forms a crystalline phenylhydrazone, $C_{12}H_{18}N_2O_3$. All attempts to prepare its osazone failed. This proves the 2-desoxy nature of corchsularose. It has not been possible to crystallize corchsularose; its molecular formula $C_6H_{12}O_4$ is calculated from these derivatives. It contains one methoxy group (determined by Zeisel's method).

Oxidative degradation of corchsularose is of great help in determining the structure. On oxidation of corchsularose diacetate (II) with 1% potassium permanganate solution, acetyl corchsularic acid, $C_{10}H_{16}O_7$ (III) is produced. Formation of this acid (III) with same number of carbon atoms as corchsularose acetate proves the presence of the —CHO group. Acetyl corchsularic acid (III), on further oxidation with 50% nitric acid, produces α-hydroxy-β-methoxyglutaric acid (V), formation of which may be thought to be by way of an intermediary acid (IV). α-Hydroxy-β-methoxyglutaric acid is also obtained from the direct oxidation of the syrupy corchsularose (I) with 50% nitric acid. α-Hydroxy-β-methoxyglutaric acid can be oxidized further with potassium permanganate and methoxysuccinic acid is obtained. The formation of α-hydroxy-β-methoxyglutaric acid (V) and methoxysuccinic acid (VI) accounts for the presence of an —OCH_3 at C-3 and —CH_2 at C-2 in the molecule of corchsularose. Thus corchsularose appears to be 2-desoxy-3-O-methylpentose.



EXPERIMENTAL[2]

Isolation of corchsularin. Finely powdered jute seeds (*Corchorus capsularis*, Linn.) in batches of 500 g. were extracted with rectified spirit (95% ethanol) in a Soxhlet apparatus. Alcohol was distilled from the extract under reduced pressure and the residue was digested with boiling water and was filtered while hot. The reddish-brown filtrate was treated with a saturated solution of lead acetate and the brown precipitate formed was filtered off. Excess of lead in the filtrate was removed by passing in hydrogen sulfide and the excess of hydrogen sulfide was carried off by a current of carbon dioxide. The brownish solution thus obtained produced needle- and prism-shaped crystals on concentration over a steam-bath. On allowing to stand in an open space more crystals appeared. The combined crystals (6 g.; m.p. 160–164° dec.) were separated from mother liquor and were dissolved in 250 ml. of rectified spirit and to the solution there was added about 75 g. of activated charcoal (Technical quality, British Drug House, Ltd.). This solution was refluxed 30 minutes, cooled, and filtered. The activated charcoal, left after filtration, was refluxed with 250 ml. of rectified spirit on a steam-bath for 30 minutes and was filtered while hot. The activated charcoal was extracted further with several portions of hot rectified spirit till no residue remained on evaporation of the alcohol extract. The combined alcohol extract, on slow evaporation, produced 1.5 g. of needle-shaped crystals, m.p. 155–156° (dec.). These crystals were dissolved in the minimum quantity of rectified spirit, boiled with activated charcoal, cooled, and filtered. This charcoal was again extracted with boiling rectified spirit in the manner mentioned before. The process of sorption and desorption by activated charcoal continued until colorless needle-shaped crystals appeared. These crystals, on further crystallization from acetone-free methanol, became thin colorless glistening needles which melted at 158° (dec). They were soluble in methanol, ethanol, acetone, acetic acid, and pyridine; sparingly soluble in water, ether, and ethyl acetate, and insoluble in chloroform, benzene, and petroleum ether. The substance had $[\alpha]_D^{25}$ 48.98° in methanol.

Anal. Calc'd for $C_{30}H_{56}O_9$: C, 64.25; H, 10.07; Mol. wt., 560.75.
Found: C, 64.24, 64.20; H, 10.08, 10.14; Mol. wt. (cryoscopic, acetic acid), 559.23, 562.50, and (camphor), 558.98, 560.50.[3]

Water of crystallization. Corchsularin crystals were dried over fused calcium chloride at 80° under a vacuum. Anhydrous corchsularin retained its original bitterness, softened at 120°, and melted at 141–142° (dec). The anhydrous variety, after crystallization from dilute methanol, melted at 158° (dec.) alone or mixed with the original corchsularin.

Anal. Calc'd for $C_{30}H_{52}O_7 \cdot 2H_2O$: C, 68.68; H, 9.99; H_2O (lost), 6.4270.
Found: C, 68.64; H, 9.95; H_2O (lost), 6.4370.

Corchsularin acetate. Acetic anhydride (20 ml.) was added to corchsularin crystals (1.25 g.), dissolved in 20 ml. of pyridine and the mixture was heated over a steam-bath for 2 hours using a reflux condenser; then it was concentrated to about 15 ml., diluted with water, and finally evaporated to dryness. The residue was taken up with alcohol and the alcoholic solution was treated with activated charcoal. The acetate finally was crystallized from dilute ethanol giving white prisms, which melted at 221–223° (dec) after several crystallizations. The acetate was readily soluble in methanol, ethanol, acetone, acetic acid, and pyridine but insoluble in water. It had $[\alpha]_D^{25}$ 54.05° (in methanol).

Anal. Calc'd for $C_{34}H_{56}O_9 \cdot 2H_2O$: C, 63.33; H, 9.54; Acetyl (for two), 13.34.
Found: C, 63.20; H, 9.52; Acetyl, 13.29.

Corchsularin in varieties of jute seeds. The powdered seeds (500 g.) of the following species and varieties of jute were extracted with alcohol in the manner described before and yield, on the dry basis of the seeds, is shown in Table I.

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[2] All melting points are corrected.

[3] Duplicate data are given to show that the molecular formula of corchsularin also may be taken as $C_{30}H_{57}O_9$, which was communicated previously.

TABLE I

AMOUNT OF CORCHSULARIN IN VARIOUS JUTE SEEDS

Species and varieties of jute seeds	Yield, %
Corchorus capsularis, Linn.	
Var. D-154...	0.30
Var. C_{39-212}	.27
Var. C_{41-13}	.24
Var. C_{42}-Nj 412	.28
Corchorus olitorius, Linn	.28

Hydrolysis of corchsularin. To 2.4 g. of corchsularin, dissolved in 100 ml. of absolute alcohol, there was added 10 ml. of conc'd hydrochloric acid. The mixture was left for 24 hours and then was concentrated to about 25 ml. on a steam-bath. On cooling, this solution produced amorphous corchsugenin (13) which was filtered and washed free of chloride. After treatment of its alcoholic solution with animal charcoal, corchsugenin was crystallized from a mixture of ether and methanol (1:1) to give light yellow prisms, which softened at 58° and melted at 74–75°. The prisms were readily soluble in methanol, ethanol, acetone, ether, ethyl acetate, benzene, chloroform, and carbon tetrachloride but were practically insoluble in water and petroleum ether. This substance $[\alpha]_D^{25}$ 60.90° (in methanol)

Anal. Calc'd for $C_{24}H_{42}O_4$: C, 73.05; H, 10.73; Mol. Wt., 394.58.

Found: C, 73.01; H, 10.88; Mol. Wt. (cryoscopic, acetic acid), 396 and (camphor), 394.8.

Water of crystallization. Anhydrous corchsugenin was prepared by drying the crystals at 56° under a vacuum over fused calcium chloride. The anhydrous variety softened at 88° and melted at 102–103° but on recrystallization from ether-methanol it softened at 58° and melted at 74–75°.

Anal. Calc'd for $C_{24}H_{40}O_3 \cdot H_2O$: C, 76.51; H, 10.70; H_2O (lost), 4.5650.

Found: C, 76.42; H, 10.65; H_2O (lost), 4.5330.

The acid filtrate, left after separation of corchsugenin, was neutralized with silver carbonate. The excess silver was removed with hydrogen sulfide and the excess hydrogen sulfide was removed from the filtrate in a current of carbon dioxide. The clear solution thus obtained was extracted with chloroform so as to remove any corchsugenin. The aqueous solution then was concentrated under reduced pressure to a syrup. It was light brown in color and all attempts to crystallize it were unsuccessful.

The hydrolysis of corchsularin also was effected with 10% sulfuric acid. However, instead of corchsugenin a solid sticky mass formed which could not be crystallized. For isolating corchsularose (13), the aqueous solution left after removal of the sticky mass was treated with an excess of barium carbonate and filtered. Water was evaporated from the filtrate on a steam-bath and the residue was digested with absolute alcohol. A light brown syrupy liquid, corchsularose, was obtained on evaporation of the alcohol.

For the present investigation hydrolysis was effected with conc'd hydrochloric acid.

Corchsularose phenylhydrazone. To a hot solution of 2 ml. of corchsularose in ethanol was added slowly a warm solution of 1 ml. of phenylhydrazine in 2 ml. of ethanol with constant stirring followed by 0.5 ml. of acetic acid. This mixture was kept in a boiling water-bath for 30 minutes until slightly yellowish crystals began to separate. An alcoholic solution of the crystals was treated with activated charcoal and was crystallized further from dilute ethanol into very light yellow-colored needles, m.p. 109–110°. These were soluble in methanol, ethanol, acetone, pyridine, and acetic acid; sparingly soluble in water and ether; and insoluble in petroleum ether, benzene, chloroform, and ligroin.

Anal. Calc'd for $C_{12}H_{18}N_2O_3$: C, 60.60; H, 7.22; N, 11.76.

Found: C, 60.56; H, 7.21; N, 11.80.

Corchsularose diacetate. The sugar (syrup) (3 g.) was mixed with 15 ml. of acetic anhydride and 1.5 g. of fused sodium acetate and was refluxed for 2 hours. The warm solution was poured upon chopped ice, and crystals of corchsularose diacetate appeared. These crystals, after separation, were dissolved in alcohol and treated with activated charcoal. Finally the diacetate was crystallized from a mixture of petroleum ether, ether, and methanol (1:1:1) into fine white needles, m.p. 123–124°. These were readily soluble in methanol, ethanol, acetone, benzene, and acetic acid; sparingly soluble in water and ether; and insoluble in petroleum ether.

Anal. Calc'd for $C_{16}H_{16}O_6$: C, 51.71; H, 6.94; Acetyl (for two), 37.07.
Found: C, 51.68; H, 6.93; Acetyl, 36.86.

Corchsularose dibenzoate. To 5 ml. of a 10% aqueous solution of corchsularose was added 1 ml. of benzoyl chloride and 12 ml. of sodium hydroxide solution (10%) and the mixture was shaken vigorously until the odor of benzoyl chloride disappeared (there was an occasional addition of alkali in order to keep the reaction mixture alkaline). The precipitate of corchsularose dibenzoate thus formed was collected and crystallized from *n*-butyl alcohol into colorless prisms, m.p. 209–210° (dec). It was soluble in methanol, ethanol, pyridine, and acetic acid; sparingly soluble in *n*-butyl alcohol; and insoluble in water, benzene, and petroleum ether.

Anal. Calc'd for $C_{20}H_{20}O_6$: C, 67.43; H, 5.62.
Found: C, 67.44; H, 5.61.

Methoxy content of corchsularose. This value was determined by Zeisel's method.

Anal. Calc'd for one group: CH_3O, 13.25. Found: CH_3O, 13.31.

Permanganate oxidation of corchsularose diacetate. The diacetate was dissolved in 200 ml. of warm water. To the cold solution was added a 1% aqueous potassium permanganate solution with stirring until the pink color persisted; then the mixture was left for 12 hours. A buff-colored colloidal solution was obtained. This was warmed and a current of sulfur dioxide was passed in to dissolve the precipitated manganese dioxide. The clear solution, thus obtained, was extracted with ether. The ether extract gave needle-shaped crystals of acetyl corchsularic acid on slow evaporation. After several crystallizations from ether, white needle-shaped crystals, m.p. 134–135°, were obtained. These were soluble in methanol, ethanol, ether, petroleum ether, and benzene but were sparingly soluble in water. The substance gave a positive Tobie-Elek (17) test for the methoxy group.

Anal. Calc'd for $C_{10}H_{16}O_7$: C, 48.38; H, 6.50; Mol. wt., 248.23; Neut. equiv. (for 1 equiv.), 248.23.
Found: C, 48.38; H, 6.43; Mol. wt. (cryoscopic, benzene), 247.50, and (camphor), 249.25; Neut. equiv., 247.27.

Nitric acid oxidation of acetyl corchsularic acid. The acid (0.5 g.) was dissolved in 40 ml. of 50% nitric acid and was left for 72 hours at room temperature. Nitric acid then was distilled off completely on a water-bath under reduced pressure. The residue was triturated with ether and a white substance was obtained on removal of the ether. An alcoholic solution of this was treated with activated charcoal. From a mixture of petroleum ether and alcohol (1:1) α-hydroxy-β-methoxyglutaric acid was crystallized in white plates, which shrank at 130° and melted at 148–149°. The compound was converted into its di-N-methylamide, m.p. 137–138° and $[\alpha]_D^{22}$ −56.25° (in water); reported (18) m.p. 138° and $[\alpha]_D^{24}$ −55° (in water).

Anal. Calc'd for $C_6H_{10}O_6$: C, 40.45; H, 5.66, Neut. equiv., (for two equiv.), 89.07.
Found: C, 40.41; H, 5.64; Neut. equiv., 89.80.

Nitric acid oxidation of corchsularose. To 4 g. of sugar syrup was added 80 ml. of 50% nitric acid and the whole was left for 48 hours at room temperature. Following the above procedure, an acid was separated and crystallized, which melted at 148–149° alone or admixed with α-hydroxy-β-methoxyglutaric acid prepared from corchsularose diacetate.

Permanganate oxidation of α-hydroxy-β-methoxyglutaric acid. To 0.2 g. of the acid, dissolved in 15 ml. of water, was added slowly over 2 hours a 1% aqueous potassium permanganate solution with stirring till there was a definite excess (about 20 ml. required); the

mixture then was left for 7 hours. Then it was made alkaline with potassium carbonate, warmed for 15 minutes at 50° to coagulate the manganese dioxide, filtered, and the precipitate washed with a little hot water. After acidification with hydrochloric acid, the filtrate was extracted with ether and the ether extract gave a white crystalline substance on evaporation of the solvent. This was further crystallized from dilute ethanol to give white needles, m.p. 107–108° alone or admixed with an authentic sample of methoxysuccinic acid.

SUMMARY

Isolation of corchsularin, a new bitter from the alcoholic extract of jute seeds, has been described. It is present in the seeds of both *Corchorus capsularis*, Linn. and *Corchorus olitorius*, Linn.

Corchsularin forms a diacetate. On acid hydrolysis it yields corchsularose and corchsugenin.

Corchsularose forms a crystalline phenylhydrazone, diacetate, and dibenzoate. From a study of its oxidative degradation products corchsularose has been shown to be 2-desoxy-3-O-methylpentose.

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