Summary

1. The occurrence of N-methyltyramine in certain strains of barley is established.
2. The significance of the occurrence of this substance in relation to the problem of the mechanism of the N-methylation of alkaloids by plants is discussed.
3. An improved synthesis for N-methyltyramine is described.

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[CONTRIBUTION FROM THE DEPARTMENT OF AGRICULTURAL CHEMISTRY, PURDUE UNIVERSITY]

The Structure of Guaran[1]

BY Z. F. AHMED[2] AND ROY L. WHISTLER

Guaran,[3] the principal polysaccharide of the endosperm of guar seeds (*Cyamopsis tetragonaloba* Taub.), is a galactomannan consisting of approximately 36% D-galactose anhydride and 64% D-mannose anhydride. In the past several years, various workers have contributed information regarding the structure of this polysaccharide. Swanson[4] has shown that the galactose units occur principally as chain ends, since from the methylated polysaccharide approximately 90% of the galactose can be recovered as 2,3,4,6-tetramethyl-D-galactose. Whistler, Li and Dvonch[5] confirmed this work by finding that on periodate oxidation of guaran one mole of formic acid is produced for approximately every three anhydroglycosidic units. While measurement of the total amount of periodate consumed seemed to agree[5] with the findings of Moe, Miller and Iwen,[6] later investigations by Mr. William Dvonch of this Laboratory[7] have shown that with excess periodate 1.33 moles of oxidant are consumed for each anhydrosugar unit. These new data in conjunction with the known amount of formic acid produced[5] suggest that in the periodate oxidation of guaran each anhydrosugar unit is split once and one out of three units is split twice. That the molecules are highly anisodimensional has been indicated by physical measurements on films of guaran triacetate.[8]

Further information on the structure of guaran is now provided by a more extensive examination of the products obtained when the methylated polysaccharide is subjected to methanolysis. The resultant mixture is shown to consist of the methyl glycosides of 2,3,4,6-tetramethyl-D-galactose, 2,3,6-trimethyl-D-mannose and 2,3-dimethyl-D-mannose in approximately equal parts. Identity of the methylated cleavage fragments is based upon their conversion to established crystalline derivatives.

One possible structural arrangement for guaran which can be deduced from the isolation and characterization of its methylated sugar units is a main chain of 1,4′-linked anhydromannopyranose units with single side units of galactopyranose linked 1,6′ to half of the mannose units. Such a structure would be in agreement with other established information on guaran. This polysaccharide is, therefore, structurally similar to that of carob bean gum.[9,10]

Experimental

Methylation of Guaran.—A well-stirred solution of guaran (30 g.) in sodium hydroxide (1500 ml. of 30%) was treated with dimethyl sulfate (450 ml.) during ten hours under nitrogen and without the application of heat.

The viscous reaction mixture was then heated to 60° while dimethyl sulfate (150 ml.) and sodium hydroxide (450 ml.) were added simultaneously during five hours. After complete reaction of dimethyl sulfate, the mixture was carefully acidified with 5 *N* sulfuric acid whereupon the methylated gum precipitated as a gelatinous, white mass.

The partially methylated gum, dispersed in water, was subjected to four more methylations by simultaneous dropwise addition of dimethyl sulfate (400 ml.) and sodium hydroxide (1000 ml.) and heating the reaction mixture on a boiling water-bath at the end of each methylation.

The crude methylated gum was dissolved in a water–acetone mixture and subjected to dialysis in cellophane tubes against water. The solution was then evaporated to dryness under reduced pressure.

The methylated gum, after repeated precipitation from chloroform solution by petroleum ether, was obtained as a white glassy mass (28 g.); yield 75%. Fractional precipitation of the methylated gum from acetone solution, by the addition of petroleum ether, showed the methyl gum to be essentially homogeneous. The methoxyl content was 45.5% and the ash content 0.8%; $[\alpha]^{20}\text{D}$ + 42° in chloroform (*c*, 1).

Methanolysis of the Methylated Guaran.—The methylated guaran (15 g.) was dissolved in methanolic hydrogen chloride (300 ml. of 1.5%) and the solution refluxed for five hours on a boiling water-bath to a constant value of $[\alpha]^{20}\text{D}$ + 68°. The methanolysis solution was neutralized with silver carbonate, filtered and concentrated to a sirup (13.5 g.).

The glycosidic sirup (10.850 g.) was distilled at 0.01 mm. and 120–160° (bath. temp.), giving a water-white viscous sirup (10.325 g.) and a non-distillable residue (0.437 g.).

Fractionation of the Distilled Glycosides.—The distilled mixture of glycosides (10.300 g.) was slowly redistilled at 0.01 mm. and a bath temperature range of 107–170°. The data for the various fractions are presented in Table I. (The total loss during the distillation amounted to 0.122 g.)

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(3) E. Heyne and R. L. Whistler, THIS JOURNAL, **70**, 2249 (1948).

(4) J. Swanson, *ibid.*, **71**, 1510 (1949).

(5) R. L. Whistler, T. K. Li and W. Dvonch, *ibid.*, **70**, 3144 (1948).

(6) O. A. Moe, S. E. Miller and N. Iwen, *ibid.*, **69**, 2621 (1947).

(7) Unpublished work, following the method of Hirst, *et al.; cf.* ref. 5.

(8) C. L. Smart and R. L. Whistler, *J. Polymer Sci.*, **4**, 87 (1949).

(9) E. L. Hirst and J. K. N. Jones, *J. Chem. Soc.*, 1278 (1948).

(10) F. Smith, THIS JOURNAL, **70**, 3249 (1948).

TABLE I

FRACTIONATION OF METHYLATED GUARAN

Fraction	Bath temp., °C.	Weight obtained, g.	n^{19}_{D}	% OCH_3
I	107–110	3.596	1.4515	60.0
II	110–118	0.643	1.4585	..
III	118–120	1.999	1.4605	52.8
IV	120–155	0.547	1.4635	..
V	155–170	3.043	1.4735	43.5
Residue	.....	0.350	....	..
Total		10.178		

Assuming that the refractive indices of the methyl tetra-, methyl tri- and methyl dimethylglycosides are n^{19}_{D} 1.4515, 1.4616 and 1.4730, respectively, the above fractions I, II, III, IV and V contained methyl 2,3,4,6-tetramethyl-D-galactoside (3.793 g.), methyl 2,3,6-trimethyl-D-mannoside (2.899 g.) and methyl 2,3-dimethyl-D-mannoside (3.142 g.). The mole ratios of the methyl tetra-, methyl tri- and methyl dimethylglycosides were 1.23:1:1.15. The amount of the 2,3,4,6-tetramethyl-D-galactoside corresponded to 38.4% of the methylated gum from which it followed that the unmethylated gum contained 34% galactose (approx.).

These figures approximate those previously reported.[3,4] In another experiment the mole ratios of the tetra-, tri- and dimethylglycosides were found to be 1.3:0.82:0.86 and the amount of galactose corresponded to 35% of the unmethylated gum.

Identification of the 2,3,4,6-Tetramethyl-D-galactose.—Hydrolysis of fraction I (2 g.) with *N* sulfuric acid at 90° for twenty hours yielded 2,3,4,6-tetramethyl-D-galactose (1.85 g.) b. p. (bath temp.) 115–120° (0.01 mm.); n^{19}_{D} 1.4675. By treatment with ethanolic aniline, it was converted to the anilide[10,11]; after recrystallization from ethanol–ether, m. p. 193°; $[\alpha]^{20}_{\text{D}}$ −140° in pyridine (*c*, 0.5), (*Anal.* Calcd. for $C_{16}H_{25}O_5N$: OCH_3, 39.8; N, 4.5. Found: OCH_3, 40.1; N, 4.5).

Identification of the 2,3,6-Trimethyl-D-mannose.—Hydrolysis of fraction III (2 g.) with 2 *N* sulfuric acid at 90° for twenty-four hours yielded 2,3,6-trimethyl-D-mannose (1.75 g.) which was dissolved in water (5 ml.) and oxidized with bromine (2.5 ml.) at room temperature for three days. The corresponding lactone was produced and, when isolated in the usual manner, gave 2,3,6-trimethyl-D-mannono-γ-lactone[10] (1.15 g.), b. p. (bath temperature) 135–140° (0.01 mm.); m. p. 84° (from ethyl acetate–ether), $[\alpha]^{20}_{\text{D}}$ +64.8° (initial in water, *c*, 0.5). The lactone yielded the phenylhydrazide[10,12]; after recrystallization from ether, m. p. 130.5°; $[\alpha]^{20}_{\text{D}}$ −20.1° in water (*c*, 0.5); (*Anal.* Calcd. for $C_{15}H_{25}O_6N_2$: N, 8.5. Found: N, 8.5), and an amide[10,13]; after recrystallization from methanol–ether, m. p. 125°; $[\alpha]^{20}_{\text{D}}$ −15.4° in water (*c*, 0.55); (*Anal.* Calcd. for $C_9H_{19}O_6N$: N, 5.9. Found: N, 5.9).

Identification of 2,3-Dimethyl-D-mannose.—Hydrolysis of fraction V (2 g.) for thirty hours at 90° with *N* sulfuric acid yielded 2,3-dimethyl-D-mannose which was converted to the corresponding lactone by bromine oxidation in the usual manner (0.8 g.), b. p. (bath temp.) 130–140° (0.01 mm.). The lactone yielded a crystalline phenylhydrazide[10,12]; after recrystallization from methanol–ether, m. p. 158°, remelting at 168°; $[\alpha]^{20}_{\text{D}}$ −25° in water (*c*, 0.5) (*Anal.* Calcd. for $C_{14}H_{22}O_6N_2$: N, 8.9; OCH_3, 19.7. Found: N, 8.8; OCH_3, 19.9).

Acknowledgment.—The authors wish to thank the General Mills, Inc., for supplying the guar flour used in this work.

Summary

Methylated guaran, obtained directly by the agency of dimethyl sulfate and sodium hydroxide, gives upon methanolysis the glycosides of 2,3,4,6-tetramethyl-D-galactose, of 2,3,6-trimethyl-D-mannose and of 2,3-dimethyl-D-mannose in approximately equal parts. These constituents have been characterized by the formation of identifiable crystalline derivatives. A proposed structure for the galactomannan is given.

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Phenyl Ketones and Derivatives of Desoxyequilenin and Desoxyisoequilenin Intermediates[1]

BY W. E. BACHMANN AND FAUSTO RAMIREZ[2]

In a study of the intermediates involved in the synthesis of desoxyequilenin and desoxyisoequilenin, the acid chlorides of *cis* and *trans* 2-carbomethoxy - 2 - methyl - 1,2,3,4- tetrahydrophenanthrene-1-acetic acid were converted into the phenyl ketones (I) by reaction with diphenylcadmium. Bromination of the *cis* phenyl ketone in acetic acid took place on the methylene group next to the carbonyl group to give the monobromoketone in 82–85% yields. The bromoketone was converted into the ketol (II) in 90% yield by reaction with sodium formate in methanol. The ketol was not affected by periodic acid at room temperature. An attempt to oxidize the ketol to the diketone IV by a boiling mixture of copper sulfate in pyridine yielded the lactone III. The pyridine was responsible for the cyclization, for the lactone resulted when the ketol was heated with pyridine alone. The presence of a ketone group in the lactone was shown by the formation of a 2,4-dinitrophenylhydrazone. The ketol reacted with lead tetraacetate in acetic acid but, instead of cleavage to an aldehyde, oxidation occurred, presumably to the diketone IV, in spite of the presence of some methanol in the mixture to promote the cleavage reaction.[3] Fusion of the oxidation product with potassium hydroxide gave 2-methyl-1,2,3,4-tetrahydrophen-

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[3] Baer, THIS JOURNAL, **62**, 1597 (1940); **64**, 1416 (1942).