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METHODS OF ESTIMATION OF CARBOHYDRATES. III.

THE CUPRIC REDUCING POWER OF THE PENTOSES—XYLOSE AND ARABINOSE.

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IN the scheme of analysis of plant extracts described in a former paper (Davis and Daish, *J. Agric. Sci.*, 1913, **5**, 437), before it is possible to calculate the proportion of dextrose and laevulose an allowance must be made for the pentoses present; it therefore became necessary to ascertain the exact value of the cupric reducing power of these sugars under the standard conditions adopted—namely those defined by Brown, Morris and Millar[1]. Values of the cupric reducing power of xylose have been given already by Stone[2], Weiser and Zeitschek[3], and of arabinose by the latter workers and by Ost[4]; but as they were obtained under conditions different from those specified by Brown, Morris and Millar, they are unsuitable for the present purpose, and it became necessary to make a fresh series of determinations. Xylose and arabinose are the only pentoses which are at all readily obtainable and in the present paper attention is limited to these.

XYLOSE.

Kahlbaum's "pure xylose" was used; the final value of the specific rotatory power when mutarotation was complete, was $[\alpha]_D^{20\cdot0} = +18\cdot76°$ ($c = 5\cdot1420$) This value was not perceptibly changed by two recrystallisations from alcohol. After such treatment, it was obtained in beautiful,

[1] *Trans. Chem. Soc.*, 1897, **71**, 72.
[2] *Ber.*, 1890, **23**, 3796.
[3] *Pflüger's Archiv*, **93**, 98; *Landw. Versuch.*, **53**, 219.
[4] *Ber.*, 1890, **23**, 3003.

slender needles $[\alpha]_D^{20\cdot0} = 18\cdot78°$ ($c = 5\cdot0755$). The results of series A were obtained with the original material; those of series B with the recrystallised xylose.

Series A.

5·1387 grms. xylose (dried to constant weight at 96° in vacuo over phosphorus pentoxide) were dissolved in water and the solution made up to 100 c.c. at 15° C. 20 c.c. of this solution, representing 1·0277 grm. xylose, were diluted to 250 c.c. at 15° C. and the reducing power determined with different volumes of this solution under the conditions specified by Brown, Morris and Millar.

TABLE I.

Volume taken	Wt. of xylose	Mean CuO *	Grms. CuO per 1 grm. xylose
50 c.c.	0·2055	0·4687	2·281
30 ,,	0·1233	0·3016	2·446
25 ,,	0·1028	0·2541	2·472
20 ,,	0·0822	0·2081	2·532
10 ,,	0·0411	0·1100	2·676

* The values given are the mean of at least two closely concordant results.

Series B.

Recrystallised xylose $[\alpha]_D^{20\cdot0} = 18\cdot78°$ (final value).

(*a*) 2·5361 grms. (dried in vacuo at 96° over phosphorus pentoxide) were dissolved in water, the solution being made up to 50 c.c. at 15° C.; 10 c.c. of this solution (= 0·5072 grms. xylose) were diluted to 250 c.c. at 15° C.

TABLE II.

Volume taken	Wt. of xylose	Mean CuO *	Grms. CuO per 1 grm. xylose
50 c.c.	0·1014	0·2506	2·471
30 ,,	0·0609	0·1550	2·545
20 ,,	0·0406	0·1049	2·584
10 ,,	0·0203	0·0543	2·675

* The values given are the mean of at least two closely concordant results.

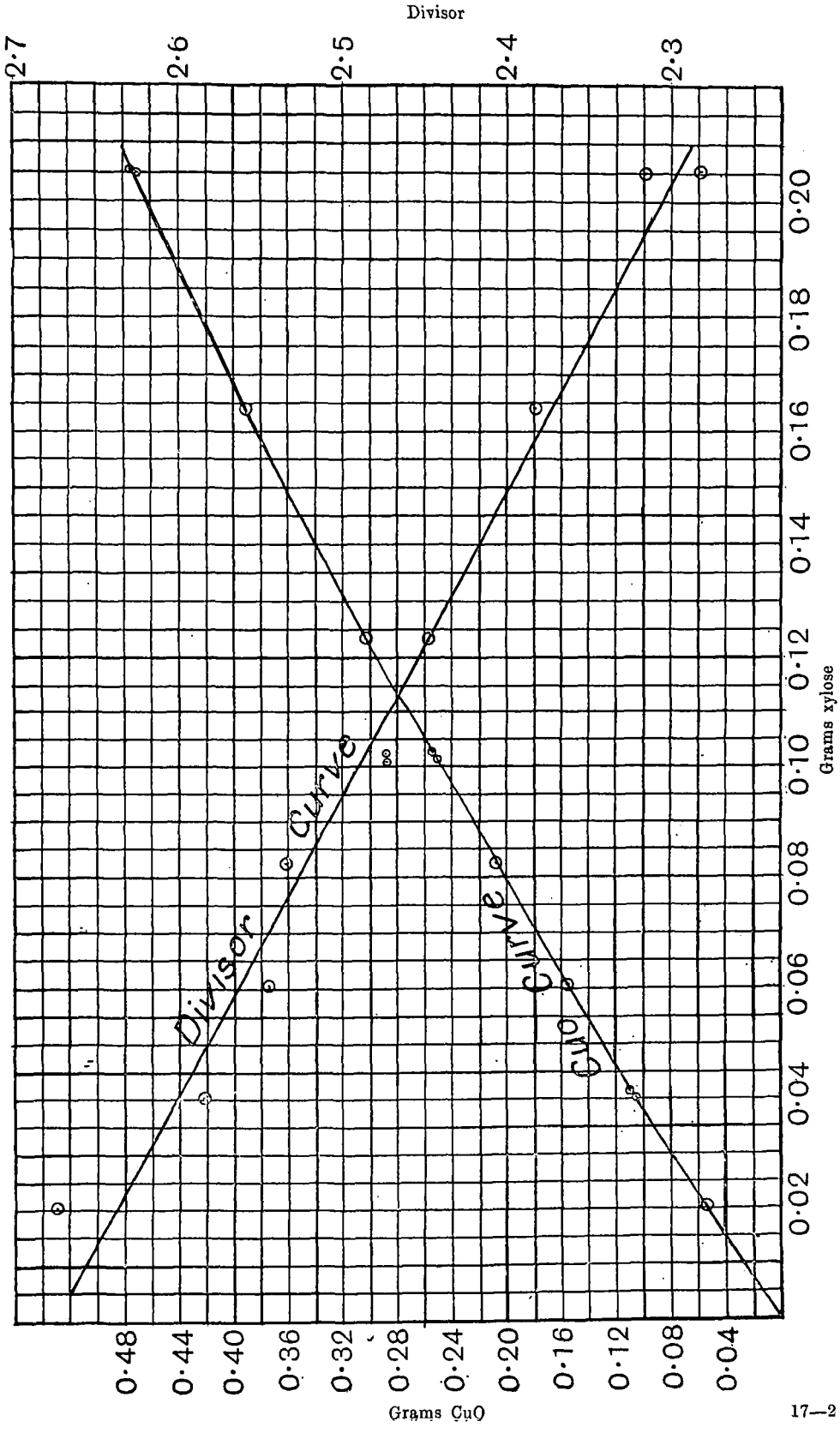

Fig. 1.

(*b*) 0·8194 grm. dry xylose dissolved in water and the solution made up to 100 c.c. at 15° C.

TABLE III.

Volume taken	Wt. of xylose	Mean CuO	Grms. CuO per 1 grm. xylose
25 c.c.	0·2049	0·4744	2·315
20 ,,	0·1639	0·3901	2·380

Fig. 1 shows the curve obtained by plotting the reducing power expressed as CuO against the corresponding weights of xylose; the "Divisor Curve" gives the value of the ratio $\frac{\text{weight of CuO}}{\text{weight of xylose}}$ for each weight of xylose. To obtain the weight of xylose corresponding to any given weight of CuO, it is best to use the "divisor curve" and to divide the weight of CuO obtained by the value of the divisor corresponding

TABLE IV. *Reducing power of xylose under the conditions specified by Brown, Morris and Millar.*

Milligrams xylose	Grms. CuO	Calculated divisor	Divisor from curve
10	0·0280	2·800	2·656
20	0·0540	2·700	2·638
30	0·0798	2·660	2·620
40	0·1040	2·600	2·602
50	0·1300	2·600	2·581
60	0·1540	2·583	2·563
70	0·1790	2·557	2·545
80	0·2030	2·537	2·526
90	0·2260	2·511	2·508
100	0·2490	2·490	2·490
110	0·2720	2·473	2·471
120	0·2940	2·450	2·453
130	0·3160	2·431	2·433
140	0·3380	2·414	2·415
150	0·3600	2·400	2·397
160	0·3810	2·381	2·378
170	0·4020	2·365	2·360
180	0·4230	2·350	2·341
190	0·4440	2·337	2·322
200	0·4640	2·320	2·304

to this weight of CuO. In Table IV are given for successively increasing weights of xylose the values of the corresponding divisors; Column 3 shows the divisor calculated from the actual weights of CuO

obtained from the "CuO curve" and Column 4 the more correct divisor obtained from the "divisor curve." When the amount of xylose is small, there is a considerable difference between the two values, such as is inherent in the nature of the method; with larger weights of xylose the agreement between the two series becomes quite satisfactory.

ARABINOSE.

The specimen of arabinose obtained from Kahlbaum was found to contain a small amount of impurity; this became evident on comparing the specific rotatory power of the original material with that of the same material after recrystallisation from 80% alcohol. The product obtained after two recrystallisations, however, gave a constant value of $[\alpha]_D$ and the same value was obtained with a specimen of arabinose specially prepared from gum arabic by hydrolysis with 2% sulphuric acid according to the method described by O'Sullivan (*Trans. Chem. Soc.*, 1884, **45**, 41; 1891, **59**, 1029). The results in series A were obtained with Kahlbaum's arabinose, twice recrystallised $[\alpha]_D^{20\cdot0} = +102\cdot14°$ ($c = 6\cdot8064$); the results in series B with the specially prepared arabinose recrystallised until the specific rotatory power was constant $[\alpha]_D^{20\cdot0} = 102\cdot33°$ ($c = 4\cdot669$).

Series A.

3·4040 grms. arabinose (dried to constant weight at 96° in vacuo over phosphorus pentoxide) were dissolved in water and the solution made up to 50 c.c. at 15° C. 25 c.c. of this solution (= 1·7020 grms. arabinose) were diluted to 250 c.c. at 15° C. and the reducing power determined with different volumes.

TABLE V.

Volume taken	Wt. of arabinose	Mean CuO	Grms. CuO per 1 grm. arabinose
30 c.c.	0·2042	0·4846	2·373
25 ,,	0·1702	0·4156	2·442
20 ,,	0·1362	0·3399	2·496
10 ,,	0·0681	0·1757	2·580
2·5 ,,	0·0170	0·0445	2·630

Series B.

Arabinose specially prepared from gum arabic. 2·3352 grms. arabinose (dried in vacuo at 96° over phosphorus pentoxide) were dissolved in water and made up to 50 c.c. at 15° C. 20 c.c. of this solution (= 0·9341 grm. arabinose) were diluted to 250 c.c. at 15° C.

TABLE VI.

Volume taken	Wt. of arabinose	Mean CuO	Grms. CuO per 1 grm. arabinose
50 c.c.	0·1868	0·4505	2·412
25 ,,	0·0934	0·2383	2·551
20 ,,	0·0748	0·1920	2·567
10 ,,	0·0374	0·0973	2·602
—	0·0234	0·0617	2·637

Fig. 2 shows the values obtained in both series plotted in the form of a curve as in the case of xylose. Table VII gives the values of the "divisor" for different weights of arabinose, at intervals of 10 milligrams.

TABLE VII. *Reducing power of arabinose under the conditions specified by Brown, Morris and Millar.*

Milligrams arabinose	Grms. CuO	Calculated divisor	Divisor from curve
10	0·0270	2·700	2·669
20	0·0540	2·700	2·654
30	0·0804	2·680	2·640
40	0·1064	2·660	2·625
50	0·1320	2·640	2·610
60	0·1570	2·617	2·595
70	0·1820	2·600	2·581
80	0·2060	2·575	2·566
90	0·2300	2·556	2·551
100	0·2540	2·540	2·536
110	0·2780	2·527	2·521
120	0·3020	2·517	2·507
130	0·3248	2·499	2·492
140	0·3476	2·483	2·477
150	0·3700	2·467	2·461
160	0·3920	2·450	2·447
170	0·4140	2·435	2·432
180	0·4360	2·422	2·417
190	0·4570	2·405	2·403
200	0·4780	2·390	2·381

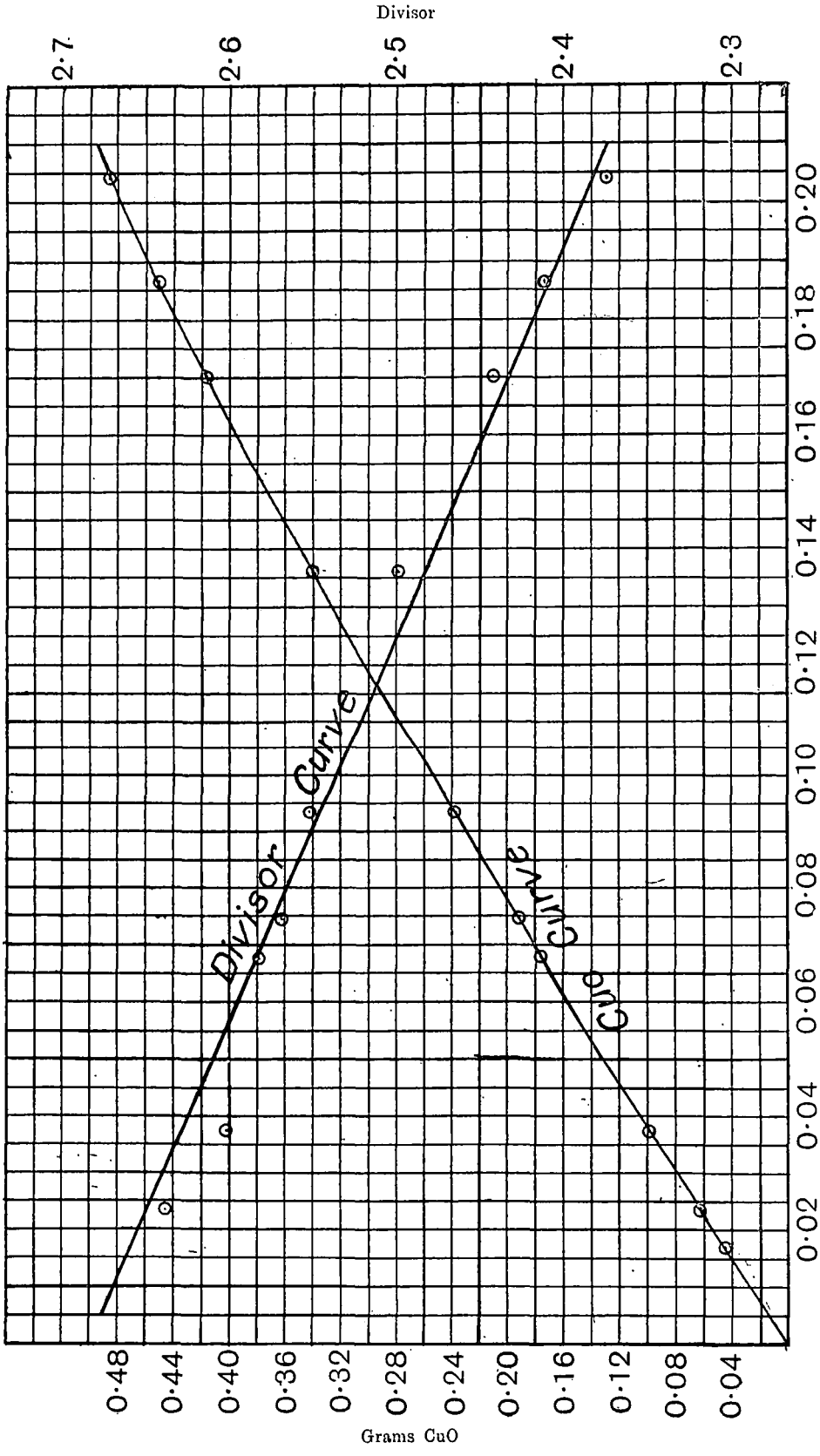

Fig. 2.

It will be seen on comparing Tables IV and VII that the reducing powers of arabinose and xylose are almost identical. For practical purposes, when working with the unknown pentoses in plant extracts, it is probable that no large error will be incurred by taking as the divisor the average value for arabinose and xylose corresponding with the weight of CuO dealt with. It is interesting to note that the reducing powers of arabinose and xylose differ only very slightly from that of dextrose; thus the divisors for these three sugars for 100 milligrams of sugar are respectively 2·536, 2·490 and 2 538.