EFFECT OF DEXTRAN ON SUGAR FACTORY PROCESSING AND POLARIMETRY

by

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SUMMARY

Some problems associated with the processing of stale cane juice containing dextran are reviewed. High dextran levels of 1.2% brix can result in a low reported overall factory efficiency as a result of its effects on the Polarimetric readings.

Such dextran present can be related to the Pol % by the correlation:

$$\log \text{Increase Pol \%} = 0.4108 \log (\text{dextran \% Pol}) + 0.0244$$

The effect of lead subacetate on dextran levels in juice and on polarimetry using Hornes dry lead method of analysis shows that lead subacetate reduces measured dextran levels. It is suggested that for good estimates of Pol reading, that the amount of lead subacetate added be adequately monitored.

When using the Borax depression method of Pol analysis in the presence of a high dextran level, the depression noted is minimal.

1. DEXTRAN AND FACTORY PROCESSING

1.1 Dextran Formation

Dextran is defined as an amorphous dextro-rotatory viscid substance produced in sugar cane through the fermentation of sucrose by Leuconostoc Genera of bacteria (7). Chemically, the name dextran covers a very large class of polysaccharides which are all characterized by being long and branched chain molecules of monosaccharide glucose (or dextrose) (1).

Industrially, dextran is produced by fermentation of a raw sugar medium by Leuconostoc mesenteroides. It is usually found in the juice of stale cane.

1.2 Effects of Dextran in the Factory

Processing difficulties caused by dextran were encountered in the beet and cane sugar industries as long ago as 1820 when high viscosity gummy slimes blocked filters and interfered with crystallization.

The main problems attributable to dextran in the sugar industry arise because of its high viscosity. It is soluble in water and aqueous sugar solutions and since about 1% of dextran can double the viscosity of sugar syrups, it only takes a very small amount of this substance to produce a significant increase in syrup viscosity.

The major processing effects can be listed below viz:

(a) The increase in viscosity of process materials can lead to decrease in factory capacity as filtration, clarification and boiling rates are reduced (4, 8, 12).

(b) The crystallization rate of sucrose is decreased up to 50% with high levels of dextran with respect to that of using fresh syrup (14). Boiling of Java Pans (6) can take up to 3 or more hours longer in the presence of dextrans.

(c) Dextran levels above 1% modifies the growth of sucrose crystals causing growth to be retarded on some faces. This results in needle shaped crystals (14). These needle shaped crystals (6) are difficult to separate from molasses in the centrifugal machines as they are generally of uneven size.

(d) For refinery operations the affination is less efficient as molasses remaining on crystals lead to difficulties in colour removal. Any dextran carried over into the refinery can cause undesirable grain formation.

Native dextran present in raw sugar crystals can cause cloudy scum filtrates (13) and reduce the polish filtration rates. Investigations have indicated that the production of raws from deteriorated cane can cause such refinery problems (13).

(e) Dextran isolated from cane juice by the author (10) had a specific rotation of 209 while sucrose has a specific rotation of 66.53 (2). As a result of this, dextran can significantly contribute to the apparent sucrose content of cane juice and factory process materials. This effect can upset process control. This can be illustrated in the following table where the effect of dextran is taken into account by assuming its Pol is equivalent to the brix multiplied by the ratio of the rotation of sucrose to dextran.

TABLE 1

EFFECT OF DEXTRAN LEVEL
OF 1.2% BRIX ON FACTORY PERFORMANCE

	REPORTED FIGURES	FIGURES TAKING DEXTRAN POL INTO ACCOUNT
Tons cane ground	15000	15000
Tons Pol in Mixed Juice	1350	1285
Tons Pol in Bagasse	150	143.84
Tons Pol in cane	1500	1428
Pol % cane	10	9.52
Tons available pol in any	1215	1119.8
BHE	90.53	98.23
WR Extraction	93.47	93.83
Overall Factory Efficiency	84.61	92.16

If the presence of dextran in juices is not taken into account when doing Pol readings on stale cane juices the reported Boiling House and overall factory efficiencies are lower than the true efficiency.

2. AIMS AND OBJECTIVES

The purpose of this investigation was as follows:

i) To establish the effect of the presence of dextran on polarimetric readings. The effect of dextran on polarimetry is further complicated by the fact that lead subacetate which is used as a clarification agent can also affect the Pol of cane juice.

ii) To investigate the effect of borax on juice with high dextran levels.

iii) To show the effect of basic lead subacetate on dextran levels in juice.

3. RESULTS

3.1 Cane Staling

In the initial stages of the investigation, dextran levels in cane juice were measured on juice from deteriorating cane. For the varieties studied under burnt and unburnt conditions, dextran levels in juice from stale cane were higher than 0.4% Brix by as early as the third day (11). For canes that are chopper harvested, results show that this level is reached within 48 hours (11). This indicated that high dextran levels are present in juices from canes. Tests done on juices from a nearby sugar factory often gave juices of dextran content above 1 to 2 % on Brix (11).

3.2 Effect of Dextran Removal on Polarimetry

In the next series of investigations the Pol of juice before and after removal of dextran by alcohol precipitation was measured.

Figure 1 shows how the weight of dextran removed from solutions caused a variation in Pol % before and after removal. When the results are plotted as Increase in Pol % against dextran % Pol, a straight line can be drawn through the points

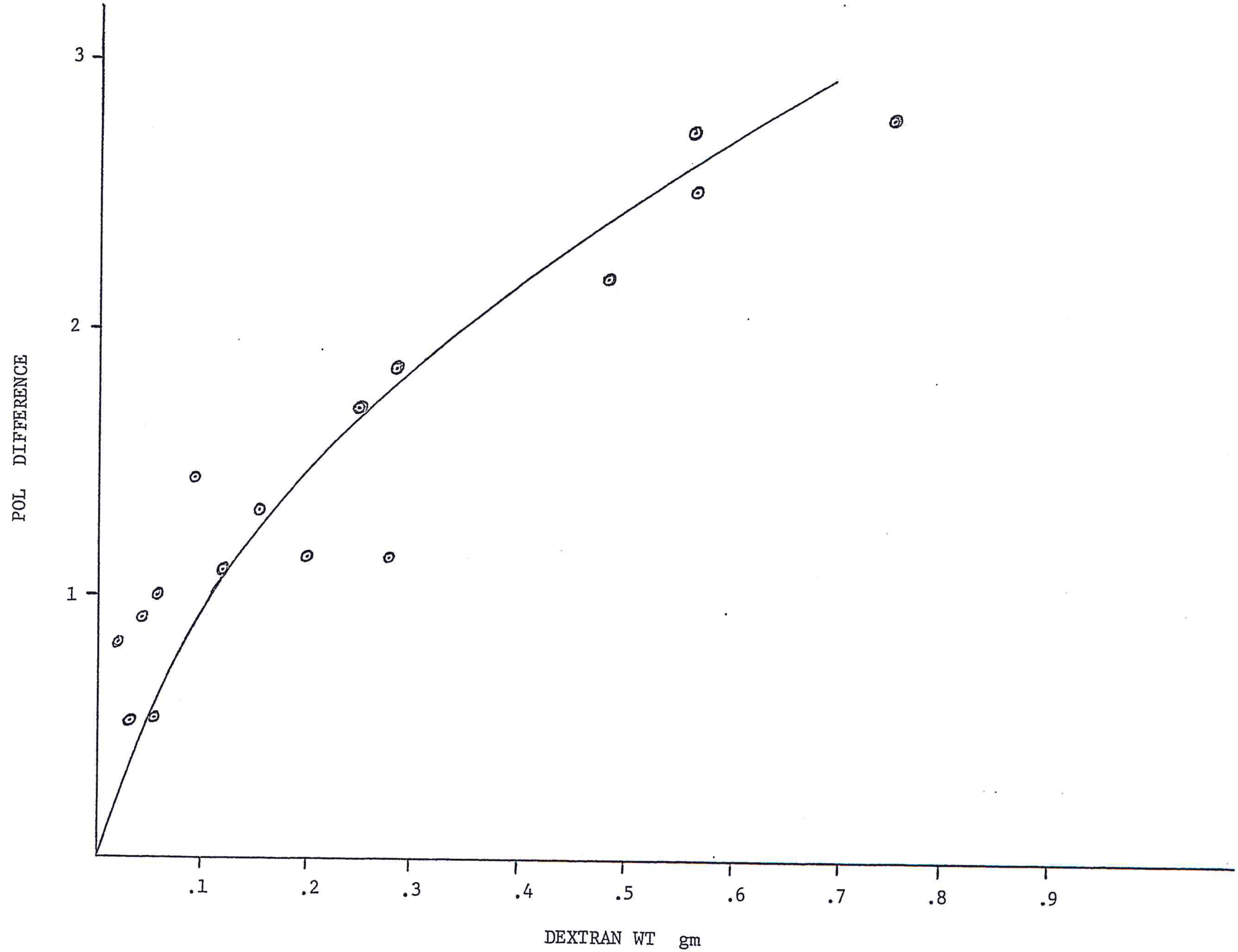

FIGURE 1

on a logarithmic plot as shown in Figure 2. The correlation obtained is as follows:

$$\text{Log I Pol \%} = 0.4292 \log \text{dextran \% Pol} + 0.05532$$

This correlation could be used to estimate the true Pol % if the dextran content of juice is known.

3.3 Effect of Dry Lead Subacetate on Polarimetry

The effect of the amount of dry basic lead subacetate on the polarimetry reading of sucrose and cane juice was investigated. It was found that the angular reading for sucrose varied linearly with the weight of basic lead subacetate used to clarify the juice as indicated in Figure 3.

For juice with negligible dextran content the variation of angular reading with lead subacetate content in 100 ml of juice was linear as shown in Figure 4. This result agrees with that determined by Guzman (5), who gave a correlation for Angular reading against Basic lead subacetate added to 200 ml of juice.

The results obtained for juice containing dextran shows a different pattern. The Pol reading tends to decrease with the amount of basic lead subacetate added. Basic lead subacetate reduces dextran level in the filtrate from Hornes dry lead polarimetric method. The amount of dextran remaining is progressively reduced as lead subacetate is added. This is shown in Table 2.

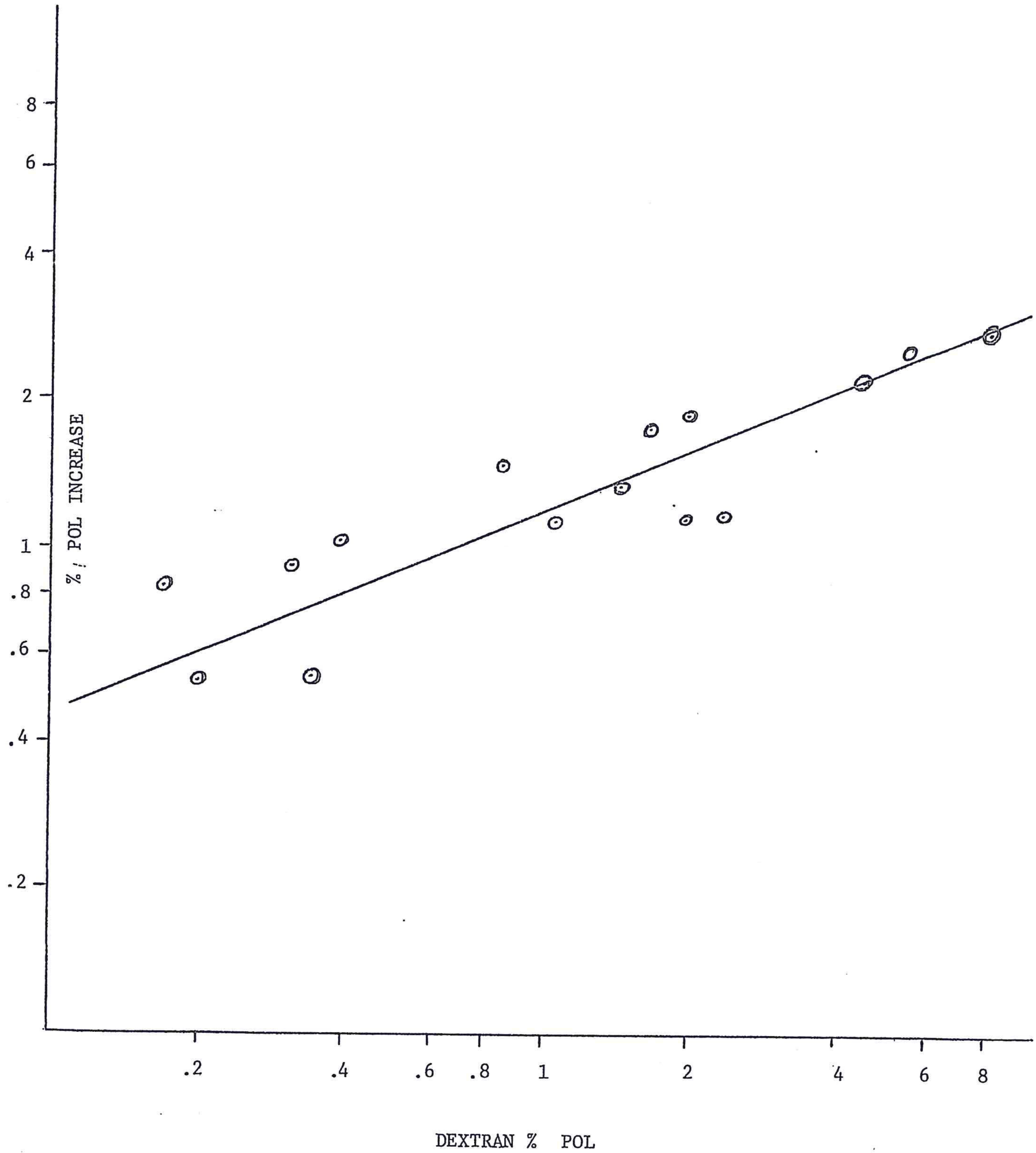

FIGURE 2

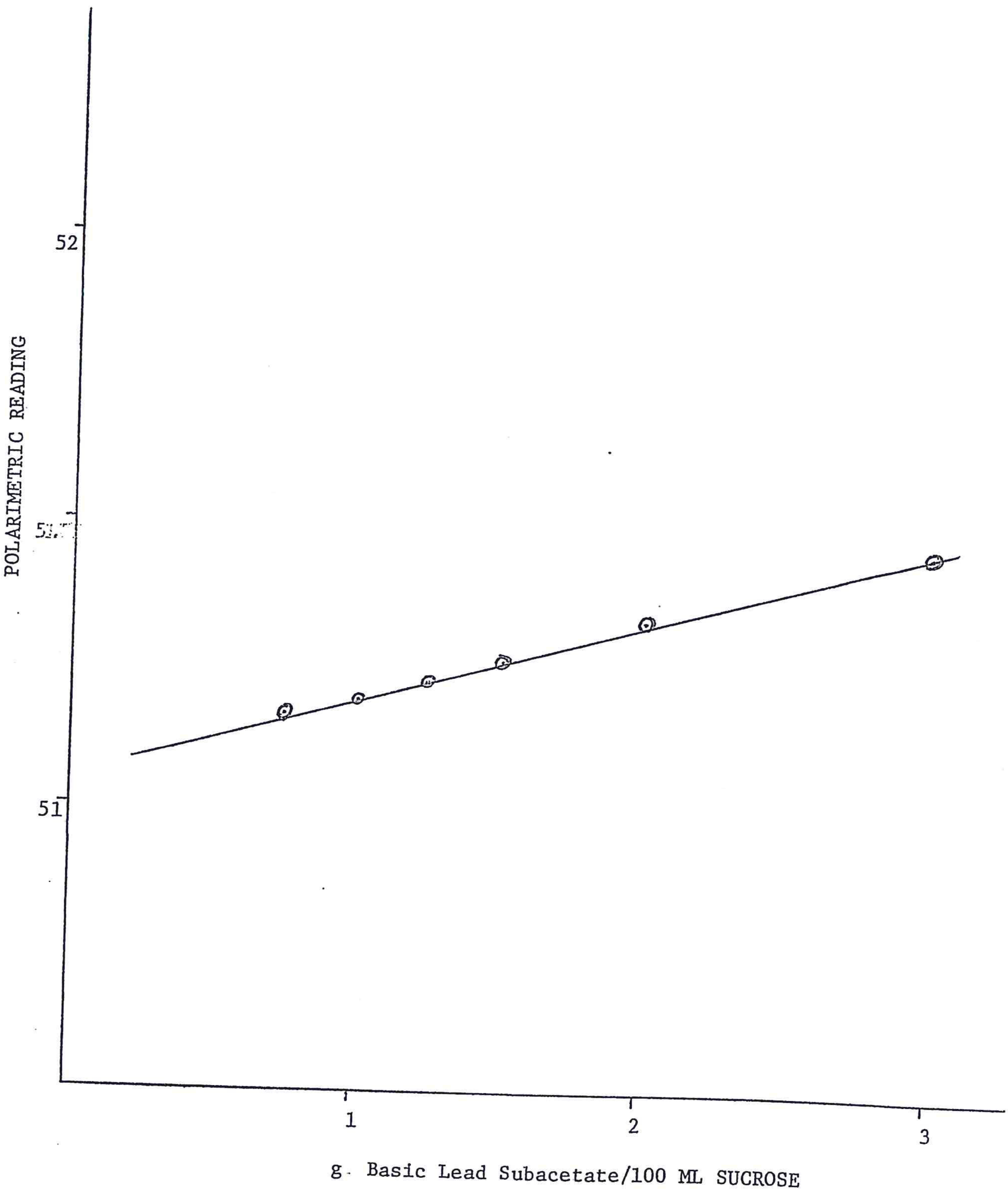

FIGURE 3: EFFECT OF BASIC LEAD SUBACETATE ON POLARIMETRIC READING OF SUCROSE SOLUTION

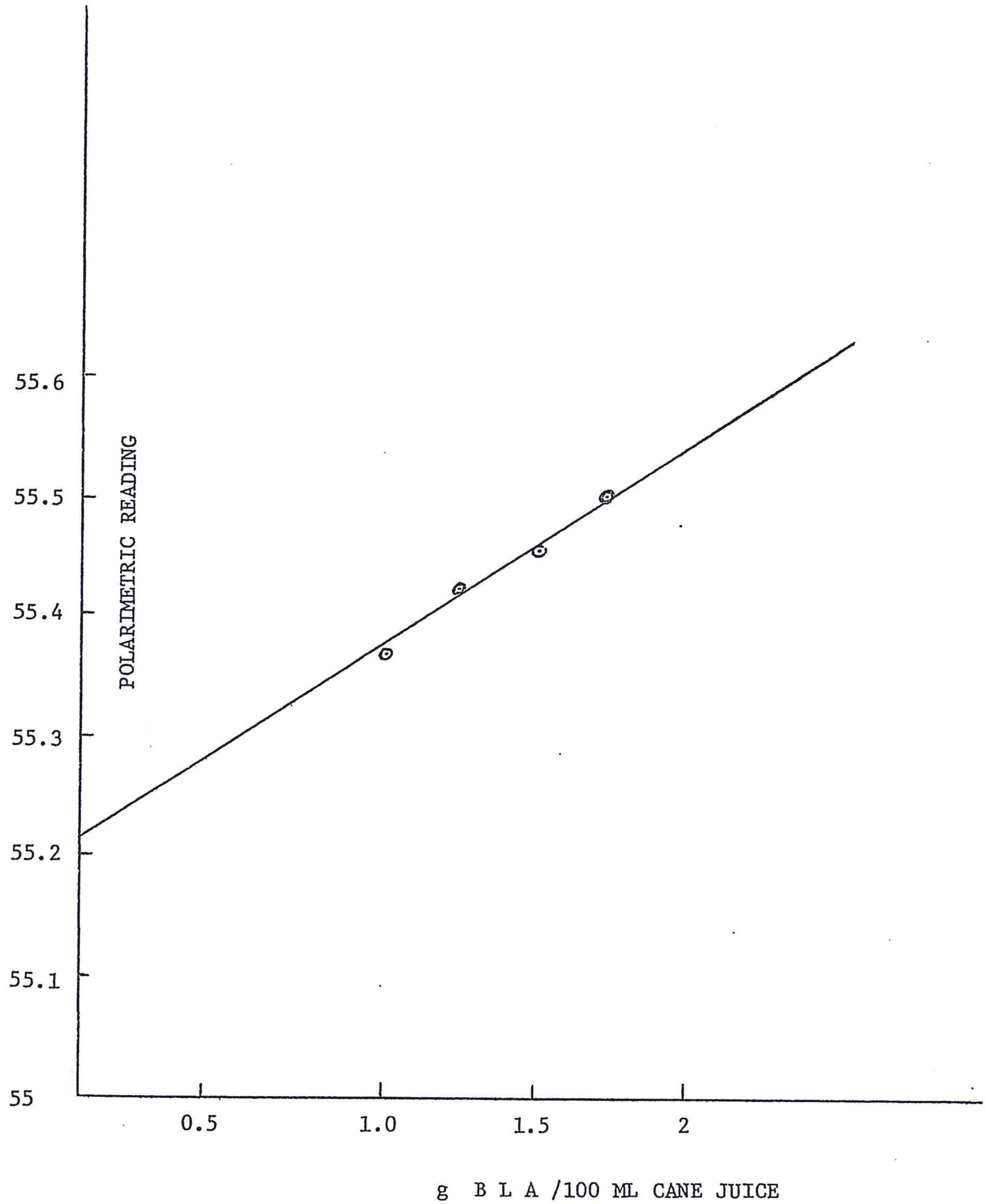

FIGURE 4: EFFECT OF BASIC LEAD SUBACETATE ON POLARIMETRIC READING OF JUICE

TABLE 2

EFFECT OF LEAD SUBACETATE
IN DEXTRAN LEVEL AND POL READINGS

Quantities of Basic Lead Sub-acetate added	Pol Reading for Juice Negligible Dextran	DEXTRAN ADDED TO JUICE		Calculated Pol Reading Increase due to presence of dextran
		Actual Pol Reading Obtained	Dextran Level in Juice or Filtrate gm/100 ml	
0			0.0360	
0.50	55.30		0.0285	
1.00	55.37	57.40	0.0172	2.03
1.25	55.42	57.11	0.0120	1.69
1.50	55.46	56.60	0.0060	1.14
1.75	55.50	55.50	0.0000	0.00
0.00			0.040	
0.75	50.06	51.99	0.0193	1.93
1.00	50.11	51.28	0.0142	1.17
1.25	50.15	51.27	0.0102	1.12
1.50	50.19	51.23	0.004	1.04

The combined effect of dextran and lead subacetate results in a reduced angular pol reading.

This pattern is also shown when the Pol % is calculated based on refractrometric brix and the formula given by Meade and Chen (3), for the calculation of % Pol.

TABLE 3

EFFECT OF LEAD SUBACETATE ON DEXTRAN LEVEL AND % POL

Lead Subacetate added	Pol % X	Expected Pol % Due to presence of Lead Subacetate (calculated) Y	Dextran Present gm/100 m.	Pol % Increase due to dextran
0.75	12.75	12.28	.0193	.47
1.0	12.58	12.29	.0142	.29
1.25	12.577	12.30	.010	.272
1.5	12.568	12.31	.004	.258
0.5	14.13	13.532	.0285	0.598
1.0	14.07	13.54	.0172	0.53
1.25	13.98	13.541	.0120	0.439
1.5	13.87	13.562	.006	0.308
1.75	13.60	13.604	.000	0.0

The lead subacetate increases the apparent Pol of the juice but at the same time the amount of dextran present in the filtrate is reduced.

The increase in Pol % attributable to dextran can be obtained by subtracting column Y from column X. This is compared in Figure 5 as a relationship between dextran % Pol and decrease in Pol % (10) obtained previously and that now calculated.

The correlation obtained was log (increase Pol %) = 0.4292 log (dextran % Pol) + .05532.

The correlation obtained by this present method gives log (decrease Pol %) = 0.4108 log (dextran % Pol) + 0.0244.

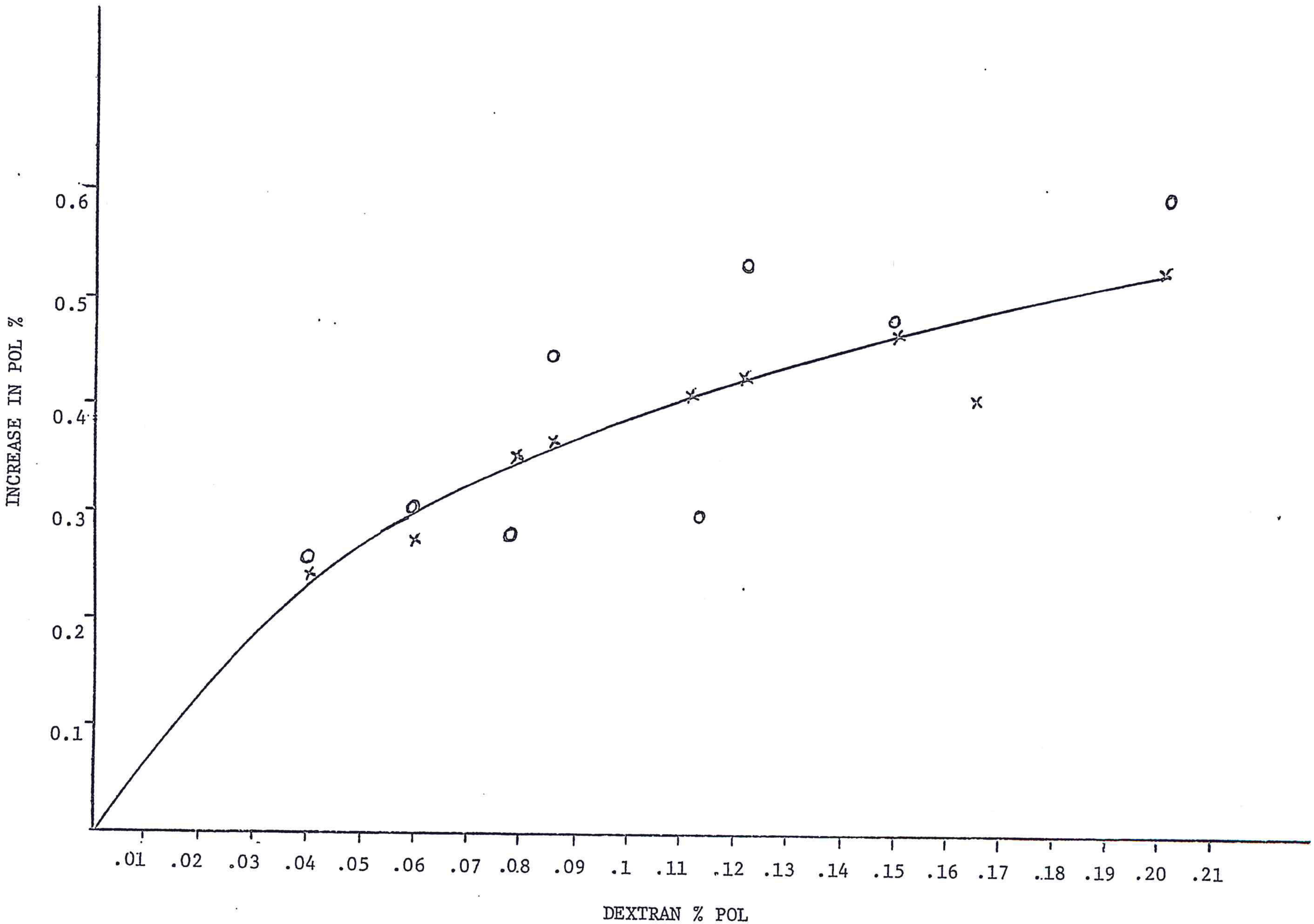

FIGURE 5: EFFECT OF DEXTRAN LEVEL ON POL %

For a dextran % Pol of 0.2 the previous correlation gives a Pol increase of 0.53 and this correlation gives a Pol increase of 0.529 which is quite close.

3.4 The Effect of Lead Subacetate on Dextran in Juice

As the level of lead subacetate added to the juice increases the dextran level in the filtrate drops. This value is dependent on the original dextran level present in the juice. Table 4 shows the pattern obtained on the addition of lead subacetate.

TABLE 4

EFFECT OF LEAD SUBACETATE ON DEXTRAN LEVEL IN FILTRATE

Wt. of Lead Subacetate added grams/100 ml juice	DEXTRAN LEVEL IN FILTRATE		
	Dextran % Brix	Dextran % Brix	Dextran % Brix
0	0.220	0.44	0.72
0.50	0.180	0.365	
1.00	0.090	0.360	0.57
1.25	0.123	0.256	0.41
1.50	0.051	0.205	
1.75	0.000	0.140	0.22

The second set of results shown in the third column of Table 4 were obtained by adding dextran to the juice. This dextran was obtained by precipitation from cane juice and purified as previously described (10). This suggests that it is possible to remove all the dextran present in the juice by adding lead subacetate. However, the lead subacetate increases the Pol. Zerban and Gamble (3) found that lead decreases the levorotation of levulose and also precipitates levulose as the lead salt. The overall result of this is the increase in Pol due to addition of lead subacetate.

Further work was done on the addition of the purified dextran to sucrose and taking the Pol readings without clarifying with lead subacetate and also clarifying with lead subacetate. This was done for sucrose solutions of differing brixes. The results are shown in Figure 6. The dextran added increases the rotation of sucrose for the brix values investigated. When a weight of approximately 1 gram of lead subacetate is added to the sucrose of varying dextran levels, the apparent Pol % shows no real trend.

Most factories add approximately 1 gram of lead subacetate during routine analysis.

It would be to the advantage of factories to weigh out at all times the amount of lead subacetate added if results are to be consistent.

If the dextran levels are known and the amount of basic lead subacetate added is known accurately the correlation obtained and the effect of the lead subacetate calculated, a fairly good estimate of the actual Pol present could be obtained.

3.5 Borax Tests

Jose Hernandez (16) postulated that borax depresses the effect of reducing sugars present and gives a Pol reading which is nearer to that of true sucrose. No work has however been reported on the effect of borax on dextran level in juice. Jennings (9) carried out an investigation using sucrose/gum solutions clarified with lead subacetate followed by additions of borax. The resultant Polarization suggested that these gums which are not neutralized by this clarification exhibit a negative polarization of up to $10^{o}S$ per gram of original gum added to 100 ml of solution.

Results obtained so far for cane juice indicate that, where the dextran level in the juice is low, there is a definite depression of the polarimetric reading.

When the precipitated .15 g/200 ml dextran is added to juice and the procedure repeated, the depression of Pol is not noticeable. This indicates that borax does not interfere with the dextran level but rather it is the amount of lead subacetate used in clarification.

This has to be verified in a further series of experiments where the level of lead subacetate and borax added is changed in fixed quantities.

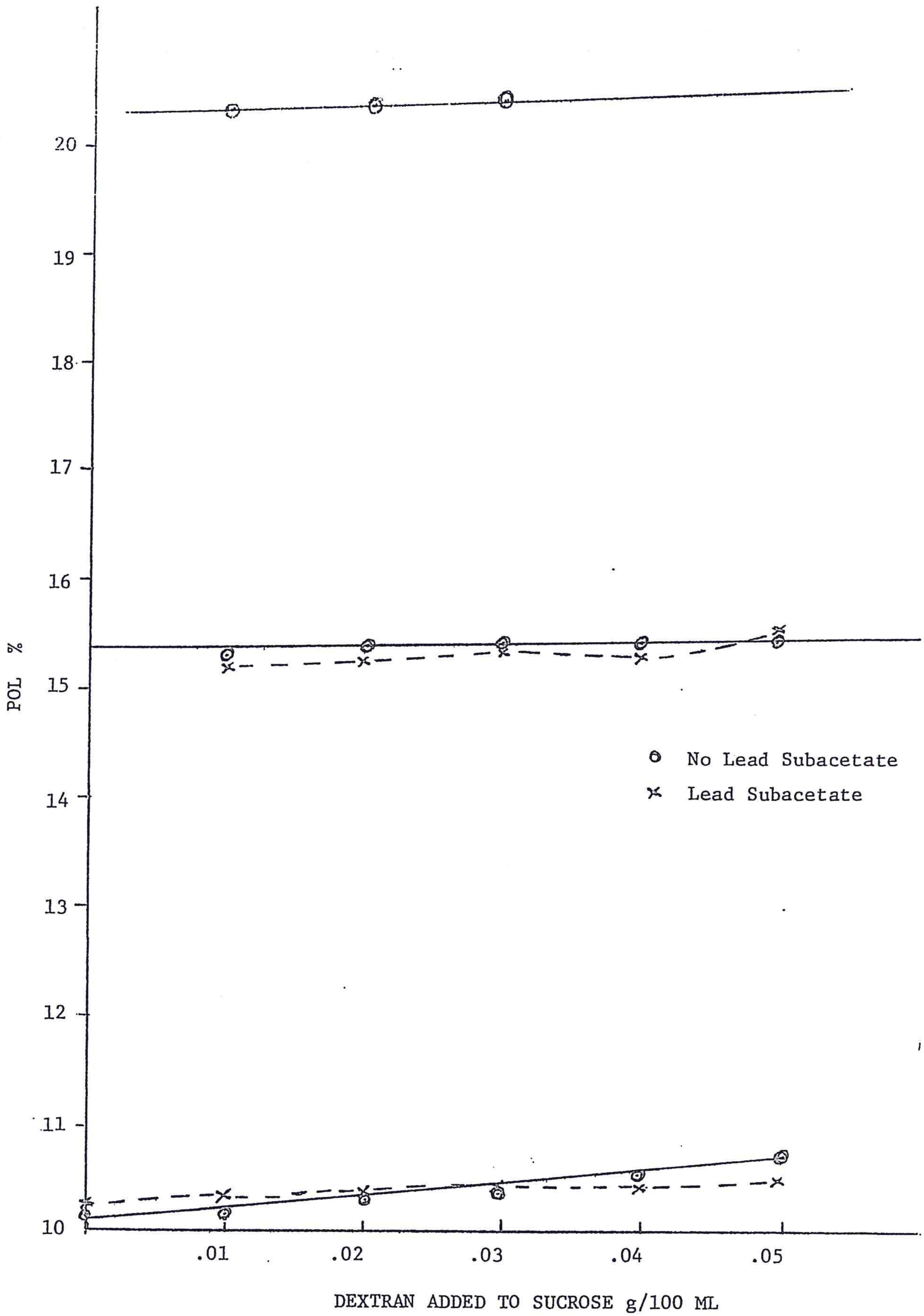

FIGURE 6: EFFECT OF DEXTRAN LEVEL ON POL OF SUCROSE SOLUTIONS

TABLE 5

EFFECT OF BORAX ON JUICE CONTAINING DEXTRAN

	Brix	% Pol	Purity	Brix	% Pol	Purity
M Juice	16.2	12.90	79.63	15.8	12.68	80.25
M Juice & Borax	16.2	12.74	78.64	15.8	11.8	74.68
M Juice & Dextran	16.2	13.05	80.56	15.8	12.28	77.72
M Juice & Borax + Dextran	16.2	13.04	80.49	15.8	12.20	77.22

M Juice = Mixed Juice

CONCLUSIONS

This series of investigation illustrated the importance of dextran determination if an accurate assessment is to be made of the process efficiency.

The optimum amount of lead subacetate suggested in literature of 1 gram per 100 ml of juice for Hornes dry lead polarimetric analysis is not sufficient to remove all dextran present in juices of stale canes.

The level of lead subacetate added should be increased to about 2 grams per 100 ml for more complete removal.

By determining the dextran level in the filtrate from Hornes dry lead analysis, the contribution of dextran to Pol of juice can be calculated from the correlation given.

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