

Some experiments on the production of Power Alcohol  
and Paper Pulp from Megasse.

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**Preliminary.**

At present 'megasse', the residual substance of sugar-cane, left after expression of the juice, is chiefly utilised as fuel. It contains some amount of unexpressed sugar as well as material hydrolysable to sugar, together with resistant fibre.

According to Browne\* crude sugar cane fibre has the following composition :—

Ash	...	1·68
Fat and wax	...	·41
Protein	...	1·94
Cellulose	...	49·00
Pentosans	...	32·04
Lignin	...	14·93

The proportion of pith and hard and soft fibres varies with different species of cane, 100 tons of cane yielding from 22 to 31 tons of megasse. Used as a fuel it has been found that 4 to 5 tons of megasse are equal to a ton of ordinary coal.

According to Raitt (Tropical Agriculturist, Jan. 1910) a paper mill would under certain circumstances be a valuable adjunct to a sugar factory and the megasse be worth then much more than its present fuel value. Where local demand exists for unbleached paper a mill producing 40 to 50 tons per week he calculates would yield a profit of £1-12-6 per ton of megasse

The experiments to be described in the following paper were undertaken therefore with the object of obtaining power alcohol from the sugar and saccharifiable matter, and fibre suitable for paper, from the residue.

A good deal of research has taken place and costly large scale trials have been made in the attempt to produce alcohol

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\* Sugar-cane by Noel Deerr p. 16.

from various forms of *wood waste* by means of acid hydrolysis under pressure followed by fermentation of the saccharine product.

Some of the principal references to this work are given at the end of this paper. Briefly it may be stated that the various methods tried include the use of different acids as hydrolysing agents or catalysts, *viz* strong and dilute sulphuric or hydrochloric acids, hydrofluoric acid, sulphurous acid and phosphoric acid, cooking at varying pressures and for different lengths of time either with or without preliminary removal of turpentine, resins, and tannins, by steam or alkali. The use of strong acids, while giving an almost quantitative conversion of the cellulose into dextrose, entails too much cost for neutralisation, to be technically possible.

Volatile acids, especially hydrochloric acid, are found to be too corrosive for the digesters or autoclaves hitherto employed. Lead linings very rapidly buckle and perish under the action of hydrochloric acid at high temperature.

The experiments of Kressmann (*Journ. Ind. Eng. Chem.*, 1914—page 625; 1915—page 920) may be quoted as affording a stand point for comparison as he worked on a semi-factory scale and under defined conditions.

He concludes that the best results are obtained when the following conditions are observed :—

- (1) Pressure of cook  $7\frac{1}{2}$  atmospheres.
- (2) Time of cook about 20 minutes.
- (3) Ratio of water to dry wood 125 : 100
- (4) do acid do  $2\frac{1}{2}$  : 100

#### General description of experimental method.

Preliminary treatment of megasse has no advantages as no serious quantity of extraneous material is present and the treatment would have the effect of removing the residual sugar remaining from the crushing operations.

In consequence the most satisfactory method to adopt in the case of megasse appeared to be to heat with sulphuric acid of such a strength and under such conditions as would give the best yield of useful products. *viz* fermentable sugar and fibre of a strength suitable for paper making.

In the first set of experiments it was only possible to heat up to 32 lbs pressure per square inch. Later on an autoclave

was obtained giving pressures up to 60 lbs per square inch. So far it has not been possible to go beyond this.

The megasse chopped into small pieces was enclosed in a glass bottle, stone-ware jar or lead container.

After a few operations the glass bottle generally cracked but the stone-ware or lead containers worked well, the former being preferable.

In no case was it possible to stir the mixture in the autoclave.

The megasse for the experiments was procured from the sugar factory at Pallapalayam and had undergone a single crushing only, followed by drying in the sun for six months.

The unexpressed sugar was first determined in the extract obtained by exhausting the megasse with boiling water and found to amount to seven percent of the weight of the megasse.

In all cases however the unexhausted dry material was submitted to acid hydrolysis.

In certain cases the operation was repeated two or three times in order to determine the ultimate effect of the process.

In the earlier stages of the enquiry a few experiments were made with sodium bisulphite as a hydrolysing agent, but it was found to be ineffective and its use was discontinued.

In all cases the sugar was determined by titration with Fehlings solution, the liquors being generally too dark to be conveniently examined polarimetrically. It is possible therefore that the results are somewhat on the high side owing to other reducing substances being present, but they are any rate comparative and the practical result is finally measured by the quantity of alcohol which can be obtained by fermentation.

#### Detailed results of experiments.

The experimental data are recorded in the following tables:—

TABLE I.

erial.	Nature of cook.	Yield of reducing sugar.				Residue.
		First cook.	Second cook.	Third cook.	Fourth cook.	
1	460 gms megasse, 5% $H_2SO_4$ at 20 lbs pressure for 4 to 5 hours.	10.3%	5.1%	1%		70%
2	$\frac{1}{2}$ lb of megasse with 2 $\frac{1}{2}$ % acid at 20—25 lbs pressure for 4 hours.	16.2%	9%	1.8%		
3	Same as in 2 except bisulphite in place of $H_2SO_4$ .	1.2%	6%	13.2%	2.8%	

In No. 1 the second cook was done with 5% bisulphite and the third with 5%  $H_2SO_4$  when charring was detected.

In No. 3 the first two cooks were done with bisulphite and the last two with  $H_2SO_4$  as the yield with bisulphite process was small.

TABLE II.

Serial	Kind of treatment.	Weight of megasse.	Weight of sugar.	Percentage of sugar.	Time of cook.	Percentage acid.
1	Pressure of cook 25 lbs ...	220 gms	23.6 gms	10.5%	4 hours	1.9%
2	do 28 „ ...	225 „	34.9 „	15.5%	3½ „	2.8%
3	do 30 „ ...	200 „	35.6 „	17.8%	2 „	5.0%
4	do 32 „ ...	235 „	59.4 „	25.3%	1¼ „	5.7%

*N. B.*—In the above table of cooks the volume of water added was just sufficient to keep the megasse immersed in it and the quantity varied from 10—12 times the weight of stuff.

The acid in all cases is calculated on the weight of the megasse.

It will be seen from Table I that the first hydrolysis gives the maximum yield of sugar. The physical condition of the hard fibre was almost the same as before treatment, while most of the pith had been dissolved out.

The second or third hydrolysis reduced the megasse to the state of sawdust without any appreciable increase in sugar. There is evidently therefore a limit to which hydrolysis can be usefully carried.

TABLE III.

Results of hydrolysis at different conditions tabulated. Weight of megasse hydrolysed one pound in all cases.

No.	Cooking pressure.	Time of cook.	% acid.	% strength of acid in water.	% sugar yield.	% weight of residue.	Remarks.
1	40 lbs.	30 min.	5.1%	.47%	30.4%	54.0%	Colour of extract lemon yellow—time of heating 2 hours
2	50 "	15 "	"	"	33.3%	53.0%	Time of heating 3 hours (prolonged).
3	55 "	30 "	"	"	32.2%	52.8%	do 2½ hours.
4	60 "	"	"	"	34.0%	50.0%	do 3 "
5	65 "	"	"	"	36.0%	52.0%	do 2 hours 10 minutes.
6	60 "	"	4.0%	.36%	35.3%	56.5%	Colour paler than 5, light yellow—time of heating 2 hrs.
7	"	"	6.4%	.56%	33.3%	54.4%	Time of heating 1 hour 50 minutes.
8	"	"	8.0%	.72%	35.3%	54.0%	do 2 hours.
9	"	"	9.5%	.86%	30.7%	55.0%	Colour deeper than 7, time of heating 2 hours.
10	"	zero "	5.1%	.47%	32.4%	54.0%	Colour of extract pale yellow—time of heating 2 hours 45 minutes.
11	"	25 "	"	"	31.4%	46.0%	Mostly pith was hydrolysed as distinct from fibre proper or outer hard rind.
12	"	45 "	"	"	33.3%	54.0%	Colour orange red—time of heating 2 hours.

In Table III are given the results of miscellaneous experiments in the autoclave where the pressure could be taken up to 60 lbs.

The following factors were afterwards systematically studied.

1. Variation of pressure
2. „ of time of cooking
3. „ of proportion of acid.

The results are given in Tables IV, V and VI.

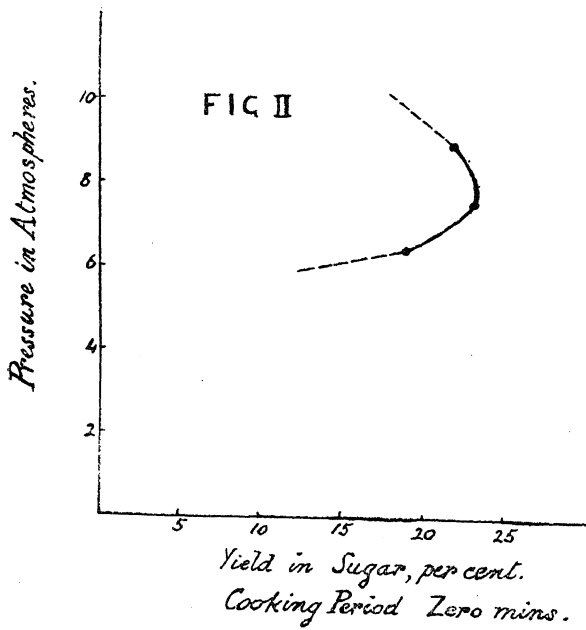
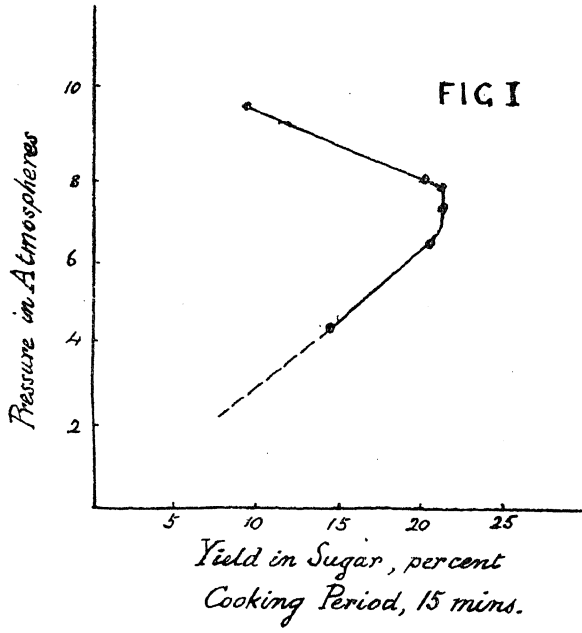
The results of Kressman who worked with wood waste under satisfactory conditions are tabulated alongside our own for the sake of comparison.

The effect of varying proportions of water to the weight of dry megasse could not be studied owing to the small volume available having regard to the bulky nature of the megasse. Generally the proportion of water added was 10 to 12 times the weight of megasse. Kressmann's results on this point are given in Table VII.

It will be seen generally that the yield of sugar from megasse is greater than from any wood waste so far dealt with. The results of previous investigations are summarised in the following statement:—

Date.	Worker.	% yield of sugar on the weight of wood waste.	% yield of alcohol.
1819	Payen	21% (pine chips)	...
	Zufferland	19.67 (saw dust)	...
1898.	Simonsen	23% (saw dust and wood waste)	7.2 %
1914	Kressman	23% (white spruce)	6 to 7.5 %
1920	Banerjee	30% (megasse)	9 %





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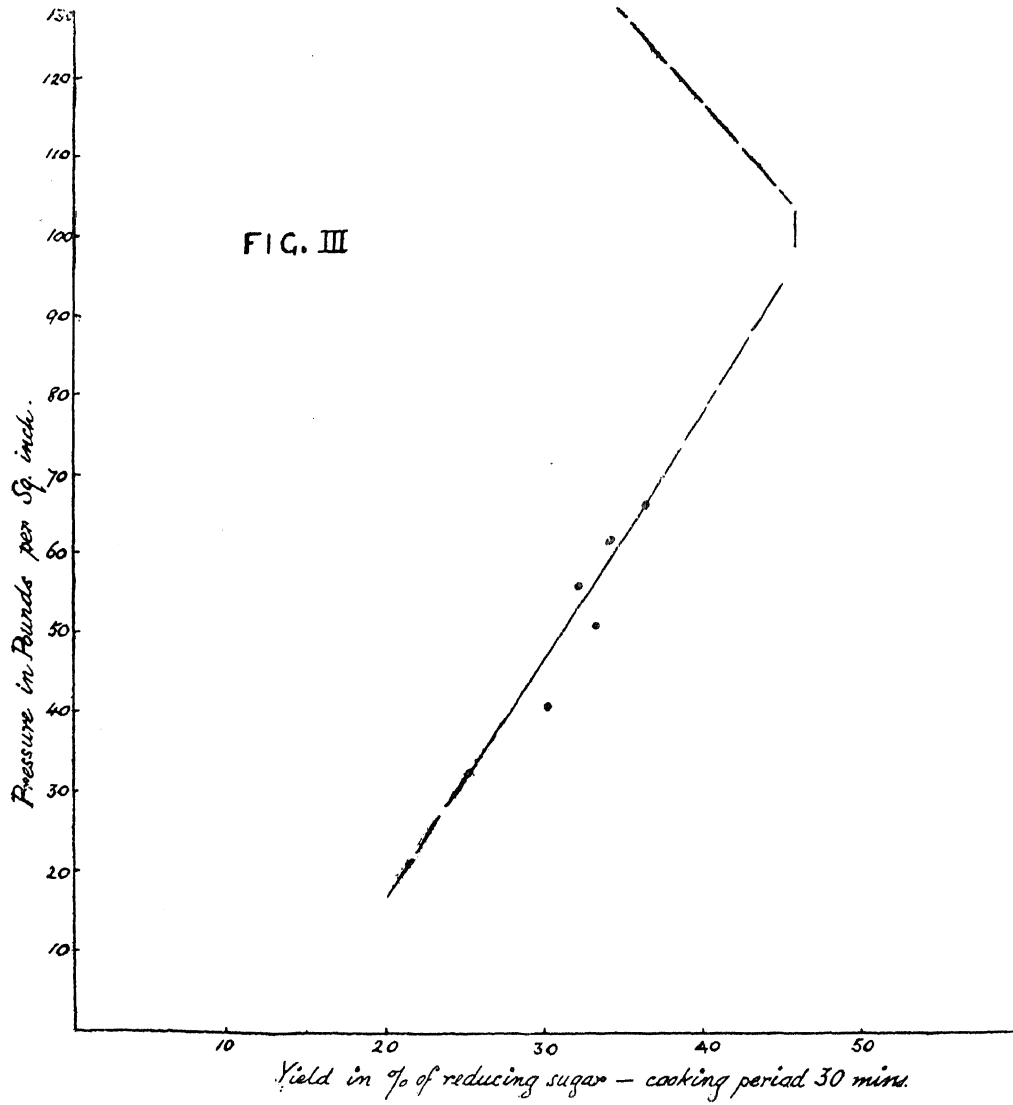


TABLE IV.

Comparative tabular results showing the result of variable factors conditioning hydrolysis—Pressure varied—other factors constant.

Pressure.	Total sugar yield.	Pressure.	Total sugar yield.
<i>Banerjee.</i>		<i>Kressmann.</i>	
40 lbs per sq. inch.	30.4%	4.25 Atmospheres.	14.3%
50 do	33.3%	0.25 "	20.5%
55 do	32.2%	7.25 "	21.5%
60 do	34%	7.5 "	23.0%
65 do	36%	8.0 "	21.5%
		9.25 "	20.0%
			9.0%

The cooking was continued for  $\frac{1}{2}$  an hour, with 5.1% catalyst acid ( $H_2SO_4$ ) in 11 parts of water.

Cooking period 15 minutes.  
Acid 1.4%  
Water 125%

The results given in Table IV show that by increasing the cooking pressure and consequently the temperature the yield of sugar is increased. There is however a limit to the increase in the yield of sugar on account of the fact that beyond a certain temperature the rate of decomposition of sugar more than balances the increased yield. This has been noted both by Neumann (Dissertation Dresden 1910) and by Kressmann (*Loc cit*). From Neumann's work it is known that dextrose decomposes rapidly above  $175^\circ C$  which corresponds very closely to 7.5 atmospheres pressure.

The results obtained by cooking at pressures of 30 lbs and upwards (see tables II & IV) are blotted graphically in Fig. III. For comparison two graphs based on those in Kressmann's paper (Journ. Ind. Eng. Chem. 1914 p 628-9) are also given (Figures I & II). From the latter the optimum pressure for maximum yield is seen to be 7.5 atmospheres. In the light of these observations the curve in Figure III has been extended along the broken line as shown and from this extension it would appear possible that a maximum yield of more than 40% may be expected if the cooking operations were carried on at 7.5 atmospheres, the other conditions remaining the same.

TABLE V.  
Time of cook variable—other factors constant.

<i>Banerjee.</i>		<i>Kressmann.</i>			
Time of cook.	Yield of sugar.	Time of cook in minutes.	Percentage total sugar.	Percentage sugar fermentable.	Percentage alcohol to dry wood.
Zero minutes	32.4%	Zero minutes	23.09	53.93	6.50
15    ,,	33.3%	10 minutes	23.45	55.08	6.45
39    ,,	34%	30    ,,	22.34	63.22	6.86
45    ,,	33.3%	Second set.			
		Zero    ,,	22.11	63.16	6.92
		10    ,,	22.36	68.53	7.662
		20    ,,	23.61	71.41	8.557
		45    ,,	21.56	77.15	8.29
		90    ,,	18.66	81.4	7.38

The cooking was done at 60 lbs pressure 5.1% catalyst acid in 11 parts of water.

Pressure of cook  $7\frac{1}{2}$  atmospheres.  
Water 125%.  
% acid 1.4 %  $H_2SO_4$  in the first set and 2.5 % in the second set.

Table V illustrates the effect of varying the time of cooking. Practical considerations require that the time of cooking should be the shortest possible. A cooking period between 10 to 30 minutes is sufficient for the actual process of hydrolysis. In this connection therefore the importance of minimising the time of preliminary heating up and of cooling or blow off is obvious and technical conditions must be arranged accordingly.

In the experiments the results of which are given in Table VI the percentage of the acid catalyst is the only variable.

The earlier experiments (Table I) showed that a variation in acid concentration between 0.36 to 0.72 grams per 100 cc. does not greatly affect the yield of sugar even when acid up to 4 to 8% of the weight of the megasse is used.

Kressmann with sawdust found an acid strength of 2.5% and a concentration of 1:1.25 to be the best but did not consider the state of the residue after the cook. With megasse however whose hard residual fibres are to be used afterwards for paper pulp the tendering of the fibres by the acid cook must be reduced to a minimum.

The actual proportion of acid to megasse used is greater in our experiments than in those of Kressmann but the concentration is less as the volume of water used was 10 to 11 times the volume of the megasse whereas Kressmann used only 1.25 times.

TABLE VI.

Weight of catalyst acid vary—other factors constant.

Percentage of acid to fibre and to added water.	Yield of sugar.	% acid H <sub>2</sub> SO <sub>4</sub> .	Total sugar%.	Percentage of sugar fermentable.	Percentage alcohol yield.
BANERJEE.			KRESSMAN.		
4.0% ... 36%	35.3%	0.5 %	17.42	43.13	4.172
5.1%— 47%	34.0%	0.75%	21.03	56.03	6.085
6.4%— 56%	33.3%	1.6 %	21.68	56.43	6.506
8.0%— 72%	35.3%	1.4 %	23.09	53.93	6.502
9.5%— 86%	30.7%	1.83%	21.53	59.98	6.623
		2.5 %	22.11	63.16	6.927
		4.0 %	21.10	66.63	7.000

Pressure cook 60 lbs.

Time  $\frac{1}{2}$  an hour in 11 volumes of water.

Pressure of cook  $7\frac{1}{2}$  atmospheres.

Cooking time zero minutes.

Water 125%.

TABLE VII.\*

Quantity of water varied—other factors constant.

Percentage water to dry wood.	Total sugar.	Percentage sugar fermentable.	Percentage alcohol yield.
<i>Kressmann</i>			
100	21.09	60.68	6.44
125	21.96	59.29	6.80
250	23.75	55.3	6.64
300	23.16	54.37	6.645
400	22.24	56.19	6.154

Pressure of cook  $7\frac{1}{2}$  atm.

Time of cook zero minutes.

Acid 1.80 to 1.85%.

In table VII Kressmann's results with different dilutions are given. In the megasse experiments it was not possible to compress the megasse sufficiently to enable the volume of water necessary to cover it to be appreciably reduced.

It has been pointed out to us by Sir Charles Bedford that the amount of water used in our experiments is economically excessive, involving subsequent cost in concentration or distillation, but as stated above the conditions of experiment did not permit greater concentration, such as could have been obtained, *e.g.* by injection of steam. On the other hand the dilution of the hydrolysing acid in our experiments ensured its even distribution throughout the mass.

Attention may be called to experiment No. 11 in Table III where the material cooked consisted mainly of the inner part or pithy constituents of the megasse. It was found that though the yield of sugar was less the loss of material was greater than when the whole cane was used. In general the weight of the residue after hydrolysis of the total fibre varied between 50 and 56 per cent of the material cooked. With the pithy portion only 46% of residue was obtained.

#### Examination of residual fibre.

In most cases the 'fibre' after hydrolysis was little affected, only the 'pith' was more or less dissolved.

To test the utility of the hydrolysed fibres for paper pulp they were treated both by the soda and sulphite process.

\*Kressmann Journ. Eng., Ind. Chem. 1915. p. 922.

The sulphite process did not give satisfactory results. By the soda process they could be treated in the same way as Esparto grass.

By the courtesy of the management of the Meenakshi Paper Mills, Punalur, Travancore State, a pound or two of the cooked fibres was boiled with soda under factory conditions and the residual stuff examined for paper pulp. It was considered fit to be used as a material for the cheaper grades of paper such as casing or wrapping paper and for all thicker sheets and boards. It would probably find its best application in admixture with other better grades of pulp such as cotton, linen, &c.

#### Fermentation of the Saccharine Extract.

The second part of the research was concerned with the study of the conditions of fermentation of the extract, and recovery of alcohol.

For this purpose some preliminary fermentations of ordinary saccharine media were carried out before attempting to deal with the extract.

Cultures of beer yeast, toddy yeast and mahua yeast were experimented with. Each grew best on its natural media and beer yeast was found to be most readily subcultured.

Beer yeast cultured in wort was therefore used in the attempt to ferment the megasse extract.

Before fermentation the extract was neutralised with lime and concentrated to 10% strength. A little acid (0.2%  $H_2SO_4$ ) and ammonium sulphate was added and then the yeast added. After all fermentation had ceased the liquor was distilled. The yield of alcohol was only 20% of the total sugar content showing that 55% of the sugar in the extract had remained unfermented.

The liquor was therefore again clarified with lime and fermented. The second fermentation yielded 5% more of alcohol making the total fermentation 50% of the theoretical.

A second experiment in which the clarification with lime was pushed a little further in the first instance yielded only 40% of the theoretical.

In a third experiment the yeast was cultivated in mixtures containing ordinary glucose with an increasing proportion of megasse extract *viz.*, 20% 40% and 75% in the hope of enabling it better to withstand the inhibiting action of non-sugars in the megasse extract. The resulting fermentation showed an



improvement the yield increasing from 40 to 60% of the theoretical, encouraging the hope that with further cultivation a yeast might be obtained capable of producing even greater yields. However even as they stand the results show a net production of some 8-9% alcohol on the weight of the megasse, comparing favourably with wood-waste from which 8.5% is the highest amount recorded.

The effect of various clarifying agents such as alumina cream, egg albumin, animal charcoal, was tried with little result. Shaking out with benzol was to some extent beneficial, as also was aeration, as evidenced by the character of the yeast growth in portions so treated, but the amount of liquid available was insufficient to obtain quantitative results.

#### Detailed investigation of extract.

For more detailed examination of the extract 15 litres of the liquor accumulated from several cooks was neutralised with lime water, filtered, and then evaporated in a steam pan under reduced pressure to an almost plastic condition. This residue closely resembled cane molasses except that it was not so sweet in taste and the characteristic jaggery smell was not so intense.

The evaporated extract was then analysed for sugar content when it was found that only 25% invert sugar was present, whereas cane molasses contain some 50%. The acid nature of the cook and the subsequent evaporation process evidently produce some caramelisation.

An attempt was made to decolorise the material with sulphur dioxide. The plastic mass dissolves completely to an almost black solution. On passing sulphur dioxide, lime compounds are precipitated and the colour changes from almost black to dark red. On reducing the acidity however, by addition of alkali or lime before fermentation the colour again darkens, so that the addition of sulphur dioxide would appear to have little value.

In order to see whether the sugars present were as a matter of fact fermentable, a careful determination was made of any pentoses present in the material.

These were determined by the phloroglucinol method, described in Browne's Handbook of Sugar Analysis, p 450.

About 5 gms of the solid were distilled with hydrochloric acid of 12 % strength (sp. gr. 1.06) 30 cc of distillate were collected every fifteen minutes and the same amount of fresh acid

replaced in the distillation flask after the same period. The distillation was judged complete when the distillate gave no pink colour with aniline acetate. The furfural in the distillate was precipitated by phloroglucinol in the cold, allowing the mixture to stand from 16 to 24 hours. The condensation product was collected in a Gooch crucible, and carefully washed with water to free it from hydrochloric acid and finally with 95% alcohol to remove the furfuroids and furaloids. (Cf. Cunningham and Dorée Biochem J 1914 p 438).

The precipitate was dried for four hours at 98—102° C cooled and weighed.

It was found that only 6% of the total reducing sugars present in the extract consisted of pentoses equivalent to 1.2% of the total weight of extract.

This result indicates that the comparatively low percentage of alcohol obtained on fermentation is not due to the sugars obtained being mainly xylose, as in the experiments of Sherrard and Blanco (Journ. Ind. Eng. Chem. December 1920 p 1160) who worked at higher pressures and with different concentration of acid, so that apparently the whole fibre was attacked and not merely the pith.

In order to obtain the highest percentage yield of alcohol it was decided to carry out a number of fermentations with mixtures in varying proportions of cane-molasses and megasse extract. The molasses was kindly supplied from the Bangalore Central Distillery.

The seed yeast was prepared as follows:—

One loop-ful of yeast (cream) was added to a tube of wort (10 cc) and incubated. When the fermentation was very vigorous (*viz.*, after 20-24 hours) it was added to 100 ccs of wort sugar medium and incubated. When this in turn had reached vigorous fermentation 100 ccs were added to a litre of the mixed solution to be fermented.

The fermentation was carried out at a temperature of 30—35° C and the rate of fermentation and total time occupied noted.

The results are given in Table VIII.

TABEL VIII.

Description.	Flask i.	Flask ii.	Flask iii.	Flask iv.	Flask v.	Flask vi.
1. Volume of wash or medium ...	1000 cc	1000 cc	1000 cc	1000 cc	750 cc	750 cc
2. Ratio of molasses to extract ...	100 : 0	75 : 25	60 : 40	40 : 60	25 : 5	0 : 100
3. Total sugars in solution ...	126 gm.	126 gm.	124 gm.	123 gm.	79 gm.	64 gm.
4. Alcohol obtained, grams per 100 cc medium, after corrections ...	5.89	5.68	4.72%	3.91	3.38	2.88
5. Percentage yield of alcohol from (3) calculated from the strength of the distillate ...	46.7%	45%	38%	32%	32%	30.5%
6. Total possible yield calculated on the basis of a 90% fermentation efficiency from molasses and 60% from the extract sugar. ...		41%	39%	36%	34.5%	
7. Difference between calculated possible yield and actual observed yield.		+4%	-1%	-4%	-2.5%	

It will be seen that the sugar strength was kept at 12% throughout, except in the case of experiment V and VI where it was reduced to a lower value in order to prevent the presence of too great a proportion of non-sugars in the liquor to be fermented, the total volume being made up by addition of distilled water.

There was little difference in the microscopical appearance of the yeasts in each case.

The non-fermented sugar was determined, after clarifying the wash with basic lead acetate, by titration with Fehlings solution.

The yield of alcohol was determined in the following way:—

100 cc of the fermented wash was distilled and when 50 ccs had distilled over the distillation was stopped. The distillate was then made up to 100 cc with distilled water and the specific gravity and temperature were noted, from which the proportion of alcohol could be calculated.

It will be seen that provided the proportion of 'extract' mixed with molasses did not exceed 25% no appreciable difference could be observed between the percentage of sugar fermented in the molasses solution and in the mixture.

With increasing percentages of extract the percentage of sugar fermented decreased.

If therefore an installation for the recovery of alcohol and paper fibre from megasse was set up in connection with a sugar factory, the megasse extract could best be fermented along with the molasses from the sugar factory.

It may be noted that the results from flask V are rather better than from flask IV although the percentage of molasses is less in flask V. This would appear to be due to the greater actual dilution of the extract in flask V.

#### Summary.

At present "megasse" the residual substance of sugar cane, left after expression of the juice is chiefly utilised as fuel. It contains some amount of unexpressed sugar as well as material hydrolysable to sugar, together with resistant fibre.

The experiments, the results of which are detailed in the foregoing paper, were undertaken with the object of obtaining power alcohol from the sugar and saccharifiable matter, and fibre suitable for paper making from the residue.

Preliminary experiments showed that dilute sulphuric acid was a better hydrolysing agent than either dilute sulphurous acid or sodium bisulphite. Owing to its corrosive action hydrochloric acid could not be employed satisfactorily in the apparatus available.

The general method followed was to heat the material in a lead or earthenware container placed inside an ordinary copper or iron autoclave.

Among the different factors conditioning hydrolysis the following have been studied.

- (a). Variation of pressure and corresponding temperature from 20 lbs to 65 lbs per sq. inch.
- (b). Variation of time of cooking from zero minutes to 5 hours.
- (c). Variation of the time of preliminary heating up to the necessary temperature from 1 to 3 hours.
- (d). Concentration and percentage of the hydrolysing acid.

The best conditions for hydrolysis are an acid strength of from 0.35% to 0.5%, and a ratio of acid to fibre not exceeding 6% of the weight of the fibre. A large proportion of acid tends to destroy the fibre and to produce non-sugars which interfere with the subsequent operation of fermentation.

The maximum yield was obtained in 15 to 30 minutes but there was not much loss when the heating was prolonged to 2 hours. The apparatus available did not permit of the pressure being raised beyond 65 lbs to the square inch. Published results (cf Simonsen *Zeit. Angew. Chem.* 1898 & Kressman—*J. I. E. Chem.* 1914 and 1915) indicate that the yield of sugar increases up to  $7\frac{1}{2}$  atmospheres, so that the present experiments may be looked upon as giving yields below the maximum possible.

The best results are obtained when the material is heated up as rapidly as possible to the required temperature and as quickly as possible cooled, so as to minimise the destructive effect of the hydrolysing acid on the fibre.

The highest total percentage of sugar recovered was 36%. The percentage of unexpressed sugar originally present in the megasse was found to be 7%. If it is assumed that 1% of the original sugar is lost during the operations of hydrolysis concentra-

tion &c., it may be concluded that 30% is produced by the hydrolysis of the nonfibrous cellular tissue of the megasse.

The saccharine solution obtained was not readily fermented by itself, even after clarification with lime. However a large percentage of it can be fermented when diluted with an ordinary fermentable solution of sugar.

The net yield of alcohol (*i. e.* apart from that derived from the sugar originally present) is then from 8—9%, comparing favourably with the best results so far obtained from wood-waste.

The fibres obtained under favourable conditions of hydrolysis of megasse can be pulped by heating under pressure with caustic soda and then form quite satisfactory material for making the cheaper and thicker grades of paper and for mixing with better grades of pulp *e. g.* from linen and cotton rags.

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| Zimmermann's Sacchulose .....      | ... | 1912.                              |
| Little .....                       | ... | 1916.                              |

and others relating to the Technical side of the process.

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