Part IV.

DISTILLERY EXPERIMENTS.

When the writer first set himself to study the conditions of the Sugar Industry of Jamaica he was forcibly struck with the enormous advantage of Rum as a by-product of the sugar process here and with the complete lack of scientific knowledge as to the nature and conditions of the manufacture of Jamaica Rum.

By the appointment of a Fermentation Chemist in 1903 it became possible to start work on the problems of Rum manufacture and during the past two years a considerable amount of work and effort has been devoted to this branch.

Mr. Charles Allan, B.Sc., the Fermentation Chemist has prepared a report upon the conditions of manufacture of Jamaica Rum based upon his personal experience in the distilleries of the island, and also his observations upon the types of microorganisms which he finds to be at work. This report appears in the final section (Part V.) of this publication and should command the interested attention of all planters who are concerned in the improvement and success of Jamaica Rum.

The records given in this section represent the first season's work in the Experimental Distillery attached to this Laboratory. They are given exactly as carried out with all their imperfections, since it was desirable to give a close and faithful record of our first season's experiences.

Many important matters still demand attention and we hesitate to draw any sweeping conclusions from the preliminary experiments. They are valuable, however, in showing the composition of the materials used in the common, clean process of rum manufacture in Jamaica and in giving the first records that have ever been obtained of the economic yield of rum from the sugars fermented in the wash.

Appliances.

Liquor was set up in puncheons holding 110 gallons each. All materials were weighed and the vessels charged by manual labour. All materials used and the liquor as set up were sampled and the essential factors determined by analysis. The liquor before distillation was again sampled and analysed Finally, the dunder produced the Rum, High Wines and Low Wines were also examined and their quality recorded. Distillation was effected in a Pot Still with double retorts holding 60 gallons at a charge. Heat is supplied from a boiler and the coil enables the distillation to be controlled with great nicety. This still was made by Messrs. Blair, Campbell and McLean of Glasgow and has given complete satisfaction.

The charge of liquor sent to the still and the High Wines and Low Wines in the two retorts were always weighed before commencing a distillation. To test any given process it is first necessary to

prepare high and low wines from the liquor itself before the final distillate—Rum is obtained. Otherwise the quality of the rum would be very largely dependent upon that of the charge of wines produced perhaps under entirely different conditions.

A practical distiller would at once observe that in several of our experiments there is a good deal of variation between the charge of wines put in the retort and that recovered from the distillation. This is unavoidable in such experiments as these where there is the greatest variation in the alcoholic strength of the liquor distilled. With systematic work, of course, it would be very simple to regulate the fractions reserved for High and Low Wines so as to secure a constant result showing a close balance between the charge and the recovered charge.

It is to be regretted that all our commercial samples of rum put up in 5 and 10 gallon barrels were spoilt through the use of tainted wooden staves by a cooper who undertook to supply new vessels for this purpose.

At the same time, most of our rums were only fit for local sale and not up to the standard of an Export Jamaica Rum. This is attributed to the absence of skimmings in most of our liquors and to the setting up of wash with a large proportion of raw cane juice.

Subsequent experiments which are not yet in a state for publication, resulted in the production of rums that should be of great value for blending purposes in the continental market. These experiments are being carried out on commercial lines on several estates in the island and as the financial verdict on the new methods has not yet been given, we leave any further reference to these experiments for a future occasion.

TERMS.

Brix.—Parts per 100 by weight of total solids expressed as sugar.

Attenuation.—Degrees Brix lost during the process of fermentation.

Sugar.—All references to sugar or Total Sugars in these records represent *Invert Sugar.*

ACIDITY.

Wash.—Pounds of Sulphuric Acid per 10 gallons of liquid.

Rum.—Pounds of Acetic Acid per 10,000 gallons of Absolute Alcohol.

Alcoholic Strength.—Results given in Proof Spirit by Syke's Hydrometer. Contraction=P.S.

Ethers in Rum.—Parts per 100,000 parts of Absolute Alcohol by volume in terms of Ethyl Acetate or Acetic Ether.

Charge on Attenuation.—The minimum yield allowed by the British Revenue Department in a distillery is one per cent. of Proof Spirit for every 5 degrees Bates (.005 S. G.) of atteuuation. Good work will give a return of 10% over this.

For average settings by common clean process in Jamaica, this charge would mean 6 gallons of rum 40 o.p. per 1,000 gallons Wash for each 1 degree Brix attenuation.

SACCHAROMETERS.

In the United Kingdom the gravities of distillery materials are determined by the Bate's Saccharometer which gives indications in terms of specific gravity. A degree Bates expresses one place in the third place of decimals in the specific gravity of a liquid.

Thus 50° Bates would represent a liquid of specific gravity 1.050 as compared with water at 60° F.

This instrument is of high accuracy but owing to the variability in our mixed materials in Jamaica, it is most difficult to sample a vat of liquor with a precision approaching the delicacy of reading of the Standard Bate's Hydrometer. As the cost is also considerable and the instrument requires careful handling it has not come into general use in this Colony and is not to be recommended for general use.

In Jamaica the commonest form of Saccharometer is the so-called Arnaboldi or Jamaica Saccharometer. I have been unable to procure a specimen of a genuine 'Arnaboldi,' all the Saccharometers now in use being by another maker.

The writer secured specimens of various instruments as used on estates and has ascertained that that the 'Arnaboldi' is really an old-fashioned Brewer's Saccharometer indicating 'pounds per barrel.'

A barrel contains 36 gallons and this would weigh at 60° 360lbs. The weight of 36 gallons of liquor in excess of 360lbs. is termed 'pounds per barrel.' Thus if a liquor is set up at 30 Arnaboldi, it means that 36 gallons of this liquor would weigh 30lbs. more than 36 gallons of water, viz : 390lbs. To avoid the errors arising from a tropical temperature the makers of the best instruments sold in Jamaica have graduated them at 80° F. I have tested several of these and find them fairly accurate.

Although it is granted that this instrument is convenient, its readings represent no concrete facts to the mind. No one in Jamaica ever deals with barrels of 36 gallons in distillery work, and the readings of the Arnaboldi's Saccharometer are therefore without any illuminating value to the distiller.

The instruments most commonly used on the Continent and in many rum-producing countries is the Balling or Brix Saccharometer. This is graduated in percentages of sugar and its readings convey information that has a direct bearing on the operations of the distillery.

Thus if a liquor stand at 20° Brix, it means that in every 100 pounds of that liquor there are 20 pounds of sugar or its equivalent in dissolved matter. We have imported a large number of Brix Spindles specially made to my specifications by Kappeller of Vienna. Each instrument is tested for instrumental error and a scale of corrections for varying degrees of temperature is supplied with each instrument. At a cost of 2/ to the department an instrument is thus provided that will read the gravity of a liquid in Brix degrees cor-

rectly to 1-10th per cent. at any temperature required. Our instruments are graduated for 30° C., or 86° F., and are thus within close range of working temperatures in the distillery.

To enable planters to compare Specific Gravity or Bate's readings with the Jamaica Saccharometer a table is now given, prepared by the writer, giving the equivalent for each degree of the "Arnaboldi" in terms of Brix and Specific Gravity.

COMPARISON OF SACCHAROMETERS.

Specific Gravity 62° F.	Jamaica Saccharometer lbs. per barrel.	Brix Saccharometer lbs. per 100 lbs.
1.000	0.0	0.0
1.003	1.0	0.8
1.006	2.0	1.6
1.008	3.0	2.1
1.011	4.0	2.8
1.084	5.0	3.6
1,017	6.0	4.3
1.019	7.0	4.8
1.022	8.0	5.6
1.025	9.0	6.3
1.028	10.0	7.1
1.031	11.0	7.8
1.033	12.0	8.3
1.036	13.0	9.0
1.039	14.0	9.7
1.042	15.0	10.5
1.044	16.0	10.9
1.047	17.0	11.6
1.050	18.9	12.4
1.053	19.0	13.1
1.056	20.0	13.7
1.058	21.0	14.3
1.061	22.0	14.9
1.064	23.0	15.6
1.067	24.0	16.3
1.069	25.0	16.8
1.072	26.0	17.4
1.075	27.0	18.1
1.078	28.0	18.8
1.081	29,0	19.5
1.083	30.0	20.0

PRELIMINARY EXPERIMENTS.

Materials for setting up experimental vats of liquor were obtained from Mona Estate. The skimmings were in a high state of fermentation and it was found necessary to sterilise them with steam in order to keep them for further use.

EXPERIMENT 1.

Set up 28th January.

330 lbs. Dunder
400 lbs. Skimmings } 16.75 Brix. Temp. 25° C.
80 lbs. Molasses

Fermentation ended in 4 days.

Brix 11.1 Temp. 25° C.

Attenuation	=	5.65
Sugar in Dunder	=	7.16 lbs.
Sugar in Skimmings	=	14.28 lbs.
Sugar in Molasses	=	45.76 lbs.
Total Sugars		67.20 lbs.
Volume of Liquor	=	76 gallons.
Sugar in Wash as set up		8.84 p.c.
Sugar in Dead Wash		2.68 p.c.
Sugar fermented		6.16 p.c.
Alcohol produced		5.61% p.s.
Acidity produced		0.52%
Proof Spirit per degree of Attenuation	=	1.0
Alcoholic yield on Sugars fermented	=	0.91 p.s.

Observations.

The yeast was in a very weak state and the skimmings full of bacteria. The attenuation was very poor and the Dunder contained 4.12% of unfermented sugar.

EXPERIMENT 2.

This was a duplicate of No. 1 and gave very similar results.

Attenuation 5.25 Brix.

Sugar in Wash as set up		8.84 p.c.
Sugar in Dead Wash		2.53
Sugar fermented		6.31 p.c.
Alcohol produced		4.64% p.s.
Acidity produced		0.74%
(Proof Spirit per degree attenuation	=	0.88

The Dunder from this experiment contained 31% sugars. Alcohol produced from sugar fermented equals 0.73 p.s.

EXPERIMENT 3.

Set up 30th January :

Fermentation ended in 5 days.

Materials.

380 lbs. Dunder	=	7.98 lbs. Sugar.
498 lbs. Skimmings (sterilised)	=	7.47 "
120 lbs. Molasses	=	84.09 "
94 gallons	=	99.54 lbs. Sugar.

Attenuation 16.2—10.5 = 5.7 Brix.

Sugar in Wash as set up	=	9.0 p.c.
Sugar in Dead Wash	=	4.9%
Sugar fermented	=	4.1%
Alcohol produced		5.86% p.s.
Acidity produced		0.16%
(Proof Spirit per degree attenuation	=	1.027).
The Dunder from this experiment contained		4.8% Sugar.

EXPERIMENT 4.

This was a trial of setting up at low gravity 12.4 Brix as against 16.2 in the previous experiment.

The materials were as follows :—

320 lbs. Dunder	=	5.76 lbs. Sugar.
400 lbs. Skimmings	=	6.04 " "
60 lbs. Molasses	=	34.32 " "
Volume = 74.5 gallons	=	46 12 lbs. Sugar.
Acidity as set up		0.343

Attenuation 12.4—7.5 = 4.8 Brix.

Sugar in Wash as set up	=	6.4 p.c.
Sugar in Dead Wash	=	1.1
Sugar fermented		5,3 p.c.

DISTILLATION RESULTS.

Charge.

Still 60 gallons (616 lbs.)

		Alcohol lbs.
40 lbs, High Wines @ 23 o.p.	=	25.06
48 lbs. Low Wines @ 83.6 u.p.	=	3.61
Total charge		28.67

Yield.

36.5 lbs. Rum @ 39.6 o.p.	=	26.7
15 lbs. H. Wines @ 19.4 o.p.	=	9.07
105 lbs. L. Wines 78.4 u.p.	=	10.45
Gross return		46.22
Deduct charge		28.67
		17.55

Nett Yield.

17.55 lbs. Alcohol from 60 gallons.
0 292 lbs. Alcohol per gallon.
36.7 gallons Alcohol per 1,000 gallons.
64.3 gallons P.S. per 1,000 gallons.
46 gallons Rum 40 o.p. per 1,000 gallons.

Proof Spirit per degree attenuation = 1.34%

N.B.—As the skimmings had fermented before use some alcohol had been produced before the wash was set up, hence the abnormal yield on attenuation.

RUM PRODUCED.

Proof Spirit	=	39.6 o.p.
Acidity per 100,000	=	14.4
Ethers	=	105.6

EXPERIMENT 5.

Spontaneous Fermentation of Skimmings.

At the outset the skimmings had the following composition :

Brix	7.5
Total Sugars	1.51
Acidity	0.098

On the 4th day the acidity rose to 0.343, after 16 days the composition of the skimmings was as follows :

Brix	3.8
Total Sugars	0.401
Acidity	0.39

EXPERIMENT 6.

At the start the skimmings were as follows :

Brix	16.0
Sugars	3.3
Acidity	0.147

On the 4th day the acidity had risen to 0.588. At the end of 16 days the Brix had fallen to 6, the sugars had almost disappeared (0,013) and the acidity had risen to 0.77.

Experiment 7.

Our first experiments had been a failure so far as obtaining a good attenuation was concerned, owing to the weak state of the yeasts and the predominance of bacteria. It was therefore decided to start a fresh fermentation with cane juice and this experiment was started on 2nd February.

Liquor was set up as follows:

Cane Juice	583 lbs.	
Dunder	383 lbs.	
Brix	=	17.35
Total Sugars	=	12.4
Acidity	=	0.7

After 5 days the wash was dead and had the following composition:

Brix	=	5.8
Total Sugars	=	0.23
Acidity	=	0.90
Alcohol as P.S.	=	10.74

The attenuation was 11.55 Brix and the Proof Spirit per degree attenuation = 0.93. Acidity developed 0.2 o/o. Yield of alcohol upon sugars fermented = 0.86 P.S.

Distillation Results.

Charge.

Still 60 gallons,		Lbs. Alcohol.
31.5 lbs. H. Wines @ 15.6 o.p.	=	18.46
92 lbs. L. Wines @ 75.2 u.p.	=	10.53
Charge	=	28.99

Yield.

42 lbs. Rum @ 39.8 o.p.	=	30.77
30½ lbs. H. Wines @ 16.0 o.p.	=	11.84
94½ lbs. L. Wines @ 73.3 u.p.	=	11.62
Gross Yield lbs. Alcohol	=	54.23
Deduct Charge	=	28.99
Nett Yield	=	25.24

Nett Yield.

0.421 lbs. Alcohol per gallon.
53.04 gallons Alcohol per 1,000 gallons.
92.95 gallons P.S. per 1,000 gallons.
66.4 gallons Rum at 40 o.p. per 1,000 gallons.
Recovery 86.5 per cent. or 4.4 per cent. below charge.

RUM PRODUCED.

Alcoholic Strength	=	36.5 o.p.
Acidity	=	21.6
Ethers	=	105.6

EXPERIMENTS 8, 9, 10 & 11.

Rum from Seedling Canes.

The result of setting up liquor with fresh cane juice resulted in vigorous fermentation and a satisfactory attenuation. The yeasts developed were almost entirely the wild, oval yeasts adherent to the canes.

We now proceeded to test the fermentation of the juice of Seedling Canes D 95 and B. 208 (Experiments 8, 9, 10 & 11) using equal quantities by volume of dunder and cane juice.

EXPERIMENT 8. D. 95. JUICE.

Materials, Equal quantities Dunder and Cane Juice.

Dunder.	Brix	17.0
	Total Sugars	4.12
	Acidity	1.26
D. 95 Juice.		
	Brix	17.45
	Total Sugars	18.01
Wash as set up.		
	Brix	16.1
	Total Sugars	11.0
	Acidity	0.58

After three days' fermentation at 27° to 24° C. the liquor died with an acidity of 0.735, and an attenuation of 8.6 Brix.

The dead liquor contained 7.87o/o Proof Spirit and 0.57 per cent. of sugars. Proof Spirit per degree Attenuation 0.71. Acidity developed = 0.155o/o. Alcohol produced from Sugars = 0.75 P.S.

DISTILLATION RESULTS.

Charge.

		Alcohol lbs.
605 lbs. Wash.		
84.5 lbs. L. Wines @ 70.8 u.p.	=	11.4
20.5 lbs. H. Wines @ 13. o.p.	=	11.62
Total Charge		23.02

Yield.

		lbs. Alcohol.
26 lbs. Rum 40 o.p.	=	18.82
18.5 lbs. H. Wines 22.1 o.p.	=	11.49
97.0 lbs. L. Wines 75.2 u.p.	=	11.10
Gross Yield		41.41
Deduct Charge		23.02
Nett Yield		18.39

Return.

0,304 lbs. alcohol per gallon.
38.3 gallons alcohol per 1,000 gallons.
67.12 gallons P S. per 1,000 gallons.
47.9 gallons Rum at 40 o.p. per 1,000 gallons.
Recovery 85.2 o/o or 7.4 o/o less than 'charge.'

Rum produced.

Alcoholic Strength	38.9 o.p.
Acidity	26.4
Ethers	105.6

EXPERIMENT 9. D. 95. JUICE.

In this experiment the wash was set up at 14.5 Brix and attenuated to 4.8 Brix in 3 days. The attenuation was therefore 9.7 Brix. The acidity ended at 0.686 o/o showing a development of 0.1 per cent.

The Rum produced was as follows:

Alcoholic Strength	35.5 o.p.
Acidity	50.4
Ethers	123.2

EXPERIMENT 10.

B. 208 Juice.

Equal quantities of dunder and juice from B. 208 were set up at 15.1 Brix and attenuated to 5.9 in 4 days with an acidity of 0.931 and an alcoholic content of 7.36 o/o P.S. = 0.8 P.S. per degree Attenuation. 'Charge' on Attenuation = 7.68o/o P.S.

Distillation.

Still 69.2 gallons = 706 lbs.

Charge.

		Alcohol lbs.
17 lbs. H. Wines @ 23.1 o.p.	=	10.66
111½ lbs. L. Wines @ 66 u.p.	=	17.56
Total Charge		28.22

Yield.

26.5 lbs. Rum 40 o.p.	=	19.45
15.5 lbs. H. Wines 30.9 o.p.	=	10.46
124 lbs L. Wines 65.9 u.p.	=	19.59
Gross Yield		49.50
Deduct Charge		28.22
Nett Yield		21.28

Return.

0.308 lbs. Alcohol per gallon.
38.8 galls. Alcohol per 1,000 gallons.
68 galls. P. S. " " "
48.6 galls. Rum 40 o.p. per 1,000 gallons.
[Recovery 92.4 o/o, 11.5o/o under Charge.]

Rum Produced.

Alcoholic Strength	40 o.p.
Acidity	31.2
Ethers	123.2

EXPERIMENT 11. JUICE OF B. 208.

Juice containing 15.74 o/o of total sugars was set up with an equal volume of Dunder at an initial density of 15.85 Brix. The wash contained 12.2 o/o sugars and started with an initial acidity of 0.44. In three days it had died down to 3.45 Brix giving an attenuation of 12.4. Acidity standing at 0.588 and Sugars reduced to 0.026 with an Alcoholic content of 10.26 o/o p.s; Equal to 0.827 Proof Spirit per degree of attenuation. Acidity developed=0.148 The 'Charge' on Attenuation equals 10.29 o/o p.s. Yield of Alcohol on Sugars=0.84 p.s.

The result of distillation were as follows :—

Charge.

Still. 6.87 lbs. Wash=68.2 gallons.

		Alcohol lbs.
15.5 lbs. H. Wines @ 30.9 o.p.	=	10.47
122 lbs. L. Wines @ 65.9 u.p.	=	19.28
Total Charge	=	29.75

Yield.

37 lbs. Rum @ 36.8 o.p.	=	26.39
14 lbs. H. Wines @ 24.8 o.p.	=	8.92
124 lbs. L. Wines @ 19.53 u.p.	=	19.53
Gross Yield		54.84
Deduct Charge		29.75
Nett Yield		25.09

Return.

0.368 lbs. alcohol per gallon.
46.36 gallons alcohol per 1,000 gallons.
81.24 gallons P. S. per 1,000
58 gallons Rum @ 40 o.p. per 1,000 gallons.
[Recovery 79.2 o/o.]

Rum Produced.

Alcoholic Strength	33.1 o.p.
Acidity	33.6
Ethers	190.

On the whole B. 208 juice fermented with the yeasts naturally adherent to the cane gave better returns and a better quality of Rum than Seedling D. 95. The rum produced from raw cane-juice and dunder is, however, of a very light type and the yield of spirit is low as compared with wash containing a higher percentage of sugar. We obtained from these fermentations a vigorous and healthy type of yeast and a dunder of good quality for further use. Our initial difficulties from the weak yeasts in the Mona materials had thus been overcome.

EXPERIMENT 12.

This experiment was started to test high setting.

Materials used.

40 gallons Dunder
24 gallons Skimmings
16 gallons Molasses

Wash as set up.

Brix	31.6
Total Sugars	25.0
Acidity	0.78

It was found that at this concentration no change whatever took place and the wash remained unchanged for 4 days.

On the fifth day the wash was diluted with water to 19.1 Brix and a content of 15.6 o/o Sugars with an acidity of 0.490. From a microscopic examination of the sour skimmings previously recorded in Experiment 5, it was noticed that the oval wild yeasts had been displaced by the small fission yeast characteristic of the fermentation where acid materials are used in Jamaica. This yeast appears to be of atmospheric origin as it was not found in the raw cane-juice. It possesses the property of attenuating a liquor in spite of a considerable acidity. The wash under experiment was therefore pitched with a quart of the sour skimmings in the hope that an acid fermentation might be started so as to give a better quality of rum. This expectation was fulfilled as proved by the following records.

Date.	Brix.	Temperature.	Acidity.
Feb 11	19.1	22.5	0.420
„ 13	18.1	22.5	0.560
„ 14	17.9	23.5	0.620
„ 15	17.6	24.0	0.670
„ 16	16.4	24.5	0.700
„ 17	14.9	25.0	0.770
„ 18	13.2	25.5	0.860
„ 19	10.2	25.0	0.970
„ 21	9.2	24.0	1.080
„ 22	8.6	23.5	1.020
„ 23	8.4	23.5	1.030
„ 24	8.0	22.5	1.040

Attenuation. 11.1 Brix.

Wash as distilled.

Brix	8.0
Sugars	0.48
Alcohol	9.18 o/o p.s.
Acidity	1.04

'Charge' on attenuation = 9.48 o/o p.s.
Proof Spirit per degree Attenuation = 0.827
Acidity developed = 0.55 o/o

DISTILLATION No. 1.

Charge.

Still and Retorts=564 lbs. Wash=548 gallons.

Return.

		Alcohol lbs.
21 lbs. H. Wines @ 5.5 u.p.	=	9.70
71½ lbs. L. Wines @ 73.6	=	8.70
		18.40

Yield

0.336 lbs. Alcohol per gallon
42.34 gallons Alcohol per 1,000 gallons
74.2 gallons p.s. per 1,000 gallons
53 gallons Rum 40 o.p. per 1,000 gallons
[Recovery 80.8 o/o.]

DISTILLATION No. 2.

The High and Low Wines from the first distillation were now used for charging the two retorts, and a second charge placed in the still.

All the products in this experiment were therefore from the same lot of liquor and the results are not affected by the High and Low Wines from a different experiment.

Charge. Still=526 lbs.=51.2 gallons.

		Alcohol, lbs.
21 lbs. H. Wines @ 5.5 u.p.	=	9.70
71.5 lbs. L. Wines @ 73.6 u.p.	=	8.70
Charge	=	18.40

Yield.

		Lbs. Alcohol.
13.5 lbs. Rum @ 36.5 o.p.	=	9.60
29.5 lbs. H. Wines @ 15.8 o.p.	=	16.20
97.0 lbs. L. Wines @ 82.1 o.p.	=	7.95
Gross Yield	=	33.75
Deduct Charge	=	18.40
Nett Yield		15.35 Lbs. Alcohol

Return.

0.3 lb. Alcohol per gallon
37.8 gallons Alcohol per 1,000 gallons
62.25 gallons p.s. per 1,000 gallons
47.3 gallons Rum @ 40 o.p.
[Recovery 72.1 o/o.]

Rum Produced.

Alcoholic Strength		36.5 o.p.
Acidity	—	55.2 o.p.
Ethers	—	422.4

Dunder Left.

Brix	—	15.2
Sugars	—	0.66
Acidity	—	1.67

The yield of Rum obtained in this experiment was not satisfactory, although the alcohol produced in the liquor was fairly good for such a type of fermentation. The quality of the rum, however, was far superior to that previously produced.

The Ethers were about four times as high and the value of the rum, commercially, probably one third more than that previously obtained.

Owing to a supply of tainted 10-gallon kegs which we obtained as new, all our rum samples were spoilt and we have been unable to obtain commercial valuations on the rums produced in our experiments. Small samples of the spirit, as distilled, were taken for analysis and we have only chemical data to go upon.

EXPERIMENT 13

This was to test an acid fermentation originating from sour skimmings when introduced into the spontaneous fermentation of raw cane juice.

Liquor was set up with the following materials:—

A.—*Fermented Cane Juice.* 487 lbs.

Acidity	—	0.55 o/o
Sugars	—	4.26 o/o
Brix	—	9.75 o/o

B.—*Dunder.* 40 gallons.

Brix	—	12.0
Sugars	—	4.796

C.—*Skimmings (soured).* 20 gallons.

D.—*Molasses.* 10 gallons.

Sugars	—	57.2
Brix	—	70.8

The composition of the Wash as set up was as follows:—

Brix	—	21.9
Sugars	—	16.55
Acidity	—	0.637

In the course of 14 days the gravity only fell 3.0 Brix while the Acidity had slowly increased to 0.93 o/o. The natural yeasts in the cane juice had now been inhibited and it was evident that the wild-yeast of the cane can not effectively ferment a liquid with an acidity over 0.6 o/o. An inoculation on the 8th day with a fermentation in which the acid-resistent fission yeast was working failed to bring about a good attenuation and it was therefore decided to add Lime to neutralise the excess of acidity. On the 15th day the acidity was reduced to 0.09 o/o in this way and in 4 days the gravity had fallen to 6.6 Brix with a total attenuation of 15.3 Brix. The final Acidity stood at 0.38.

The results of distillation were as follows:—

			Lbs. Alcohol
Charge.	Still 585 lbs. Wash=57.2 gallons.		
Retorts—	28 lbs. H. Wines @ 12.8 o.p.	=	15.83
	104 lbs. L. Wines @ 81.3 u.p.	=	7.49
	Total Charge		23.32
Yield.			
	30 lbs. Rum @ 39.8 o.p.	=	21.99
	31 lbs. H. Wines @ 20.1 o.p.	=	18.87
	100 lbs. L. Wines @ 70.3 u.p.	=	13.75
	Gross Yield		54.61
	Deduct Charge		23.32
	Nett Yield lbs. Alcohol		31.29

Returns.

0.547 lb. Alcohol per gallon
68.92 gallons Alcohol per 1,000 gallons
120.8 gallons P.S. per 1,000 gallons
86.3 gallons Rum 40 o.p. per 1,000 gallons
Recovered Proof Spirit per degree Attenuation=0.79 o/o
92 o/o on Attenuation 'Charge.'

Rum Produced.

Alcoholic Strength	39.8 o.p.
Acidity	50.4
Ethers	123.2

Experiments to test the most Favourable Concentration for producing Rum from Cane Juice.

EXPERIMENTS 14, 15, 16, 17, 18.

Some of the most famous drinking rums have been produced from the whole contents of the cane juice without extracting any sugar at all. Appleton Estate in St. Elizabeth where the famous "Appleton" drinking rum is made operates in this way and a series of experiments was started to throw light on the matter.

In order to be able to compare the rums produced in each experiment it is necessary to prepare wines from the material itself, or else the resultant spirit will not be representative of the fermentation it is desired to test. To do this wash was set up in duplicate vessels. In order to imitate the conditions that obtain on an estate making rum only, molasses was added to the cane juice and dunder to give the desired concentration.

Wash was set up at 22, 20, 17.5, 16.5, and 15 5 Brix, and the results are now given in detail.

EXPERIMENT 14. WASH SET UP AT 22.0 BRIX.

Materials.

A. 372 lbs. Dunder.
B. 775 lbs. Cane juice.
C. 28 lbs. Molasses.

A. Dunder.

Brix	—	6.65
Sugars	—	0.03
Acidity	—	1.36

B. Molasses.

Total Sugars	6.66

Wash as set up.

Brix	—	22.2
Total Sugars		16.39
Acidity	—	0.26
Alcohol	—	0.26

In 9 days the liquor had died down to 7.0 Brix with an attenuation of 15.2 Brix. The initial temperature was 26° C., this rose to 34° C., on the second day and gradually died down to a minimum of 21.5, The initial acidity of 0.26 steadily increased throughout and ended at 1.26 %. The dead liquor contained.

0.21 %	Sugars
12.42 %	Proof Spirit*

Alcoholic yield on sugars fermented=0.77 P.S.
P.S. per degree of attenuation=0.818
Acidity developed=1.0 %
Attenuation Charge equals 13.08 % P.S.

* This result is undoubtedly too low v. distillation results.

RESULTS OF DISTILLATION.

First Distillation.

Charge.

Still 616 lbs.=60.1 gallons.

1st Retort	—	109 lbs.
2nd Retort	—	51 lbs.
Total	—	776 lbs=75.8 gallons

Yield.

		lbs. Alcohol
91.5 lbs. L. Wines @ 62.9 u.p.	=	15.78
34.5 lbs. H. Wines @ 6.5 o.p.	=	18.25
Total Yield		34.03

Return.

0.566 lbs. Alcohol per gallon
71.32 gallons Alcohol per 1,000 gallons
124.98 gallons P.S. per 1000 gallons
98.3 gallons Rum 40 o.p. per 1,000 gallons
[Recovery 95.5 o/o on charge on attenuation.]

Second Distillation.

Charge.

Still=668 lbs.=65.2 gallons.

		lbs. Alcohol.
91.5 lbs. L. Wines @ 62.9 u.p.	=	15.78
34.5 lbs. H. Wines @ 6.5 o.p.	=	18.25
Total Charge lbs. Alcohol		34.03

Yield.

58 lbs Rum @ 39.1 o.p.	=	42.2
28 lbs. H. Wines @ 8.5 o.p.	=	15.1
100 lbs. L. Wines @ 81.5 u.p.	=	8.5
		65.8
Deduct Charge		34.0
Nett yield lbs. Alcohol		31.8

Return.

0.487 lbs. Alcohol per gallon
61.36 gallons Alcohol per 1,000 gallons
107.54 gallons P.S. per 1,000 gallons
76.8 gallons Rum 40 o.p. per 1,000 gallons
[Recovery=86.5 o/o.]

Rum Produced.

Alcoholic Strength	39.1 o.p.
Acidity	14.4
Ethers	126.7

EXPERIMENT 15. WASH SET UP AT 20.0 BRIX

(1) *Materials.*

A. 320 lbs. Dunder
B. 662 lbs. Cane juice
C. 65 lbs. Molasses

A. *Dunder.*

Brix	—	11.2
Sugars	—	0.61
Acidity	—	0.92

C. *Molasses*

Brix	—	70.8
Sugars	—	57.2

Wash as set up.

Brix	—	20.2
Sugars	—	16 6
Acidity	—	0.33

Fermentation was over in 4 days. Temperature rose to 34° C., on the second day and fell to 23.5° C., on the fourth. The Acidity rose to 0.56, the attenuation was 17° Brix and the wash contained 15.3o/o Proof Spirits only a trace of Sugars remaining unfermented. *Proof Spirit per degree of attenuation=0.90. Acidity developed=0.23 o/o.

(2) A second lot set up in a similar way gave the following results :—

Materials.

A. 320 lbs. Dunder
B. 75 lbs. Molasses
C. 734 lbs. Cane Juice.

A.—Dunder.

Brix	—	10.7
Sugars	—	0.15
Acidity	—	0.94

B.—Molasses.

Brix	—	70.8
Sugars	—	57.2

C.—Cane Juice

Brix	—	19.3
Sugars	—	19.83

Wash as set up.

Brix	—	20.0
Acidity	—	0.32
Sugars	—	17.05

Fermentation ceased in 4 days, the temperature rising to 35° C. on the second day. The Acidity only rose to 0.84 o/o. Only 0.05 % Sugars remained unfermented.

* Alcoholic Yield on Sugars fermented equals 0.927 P.S.

The Attenuation was 18° Brix and the dead wash contained 17.0% of Proof Spirit, Proof Spirit per degree Attenuation 0.94. Acidity developed = 0.16, The 'Charge on Attenuation = 15.1 o/o p.s. The yield of Alcohol on sugars = 1.00 p.s.

DISTILLATION RESULTS.

(1) *Charge.*	Still 642 lbs. = 64 gallons.		Alcohol.
	48 lbs. H. Wines @ 13.2 o.p.	=	27.25
	100 lbs. L. Wines @ 45.8 u.p.	=	25.45
	Total Charge		52.7
Yield.			
	74.5 lbs. Rum @ 42.7 o.p.	=	56.0
	48.5 lbs. H. Wines @ 25.8 o.p.	=	31.2
	100 lbs. L. Wines @ 75.5 u.p.	=	11.3
	Gross Yield		98.5
	Deduct Charge		52.7
	Nett Yield		45.8

Returns.

0.716 lbs. Alcohol per gallon
90.21 gallons Alcohol per 1,000 gallons
158.1 gallons P.S. per 1,000 gallons.
112.9 gallons Rum 40 o.p. per 1,000 gallons
[Recovery 93 o/o, 4.7 o/o above 'Charge'

(2) *Charge.*	Still 500 lbs. = 9.74 gallons.		Lbs. Alcohol.
	48.5 lbs. H. Wines @ 25.3 o.p.	=	31.06
	99.5 lbs. L. Wines @ 75.7 u.p.	=	11.20
			42.26
Yield.			
	59 lbs. Rum @ 43.5 o.p.	=	44.65
	38.5 lbs. H. Wines 25.8 o.p.	=	24.77
	67 lbs. L. Wines @ 74.1 u.p.	=	8.01
	Gross Yield		77.43
	Deduct Charge		42.26
	Nett Yield		35.17

Return.

0.708 lbs. Alcohol per gallon
89.2 gallons Alcohol per 1,000 gallons
155.33 gallons p.s. per 1,000 gallons
111.7 gallons Rum 40 o/o per 1,000 gallons
Recovery 92 o/o or 3.5 o/o over 'Charge.'

Rum Produced.

Alcoholic Strength	42.7 o.p.
Acidity	4.1
Ethers	70.4

Experiment 16.

Wash set up at 17.5 Brix.

Materials

A. 320 lbs. Dunder
B. 349 lbs. Cane Juice
C. 71 lbs. Molasses.

A—*Dunder.*

Brix	—	10.6
Sugars	—	0.66
Acidity	—	0.96

C—*Cane Juice.*

Brix	—	18.5
Sugars	—	17.83

C—*Molasses.*

Brix	—	70.8
Sugars	—	57.2

Wash as set up.

Brix	—	17.5
Sugars	—	13.6
Acidity	—	0.33

After 4 days the liquor attenuated to 2.0 Brix=15.5.° The temperature rose to 34.5° C. The final acidity was 3.51.

A duplicate experiment gave an attenuation of 15.6 with a final acidity of 0.50.

The Sugars had been reduced to the merest traces 0.03 and 0.05 per cent. in the two cases The Alcoholic content was 14.4 and 14.8 per cent. P.S. Average 14.6 per cent.

Proof Spirit per degree attenuation=0.94

Yield of Alcohol on Sugars fermented equals 1.07 p.s.

Attenuation 'Charge'=12.9 % p.s.

Distillation Results.

(1) *Charge.*

Still 717 lbs.=71.3 gallons.

		Lbs. Alcohol.
44 lbs. H. Wines @ 8.8 o.p.	=	23.87
95 lbs. L. Wines @ 55.1 u.p.	=	15.79
Total Charge	=	39.26

Yield.

51 lbs. Rum @ 42.1 o.p.	=	38.13
47 lbs. H. Wines @ 24.6 o p.	=	29.90
107 lbs. L. Wines at 82.3 u.p.	=	8.83
Gross Yield		76.86
Deduct Charge		39.26
Nett Yield		37.60

Return.

0.527 lbs. Alcohol per gallon.
66.4 gallons Alcohol per 1,000 gallons.
116.38 gallons P.S. per 1,000 gallons.
83.1 gallons Rum 40 o.p. per 1,000 gallons.
Recovery 80 %, or 9.8 % under charge.

(2) *Charge.*

Still 584 lbs.=58.1 gallons.

		Lbs. Alcohol.
47 lbs. H. Wines @ 24.4 o.p.	=	29.84
108 lbs. L. Wines @ 81.9 u.p.	=	9.00
Total Charge		38.84

Yield.

52 lbs. Rum @ 42 o.p.	=	38.84
33 lbs. H. Wines @ 23.2 o p.	=	20.71
98.5 lbs L. Wines @ 74.6 u.p.	=	11.52
		71.07
Deduct Charge		38.84
Nett Yield		32.23

Return.

0.554 lbs. Alcohol per gallon
69.8 gallons Alcohol per 1,000 gallons
122.33 gallons P.S. per 1,000 gallons
87.4 gallons Rum 40 o.p. per 1,000 gallons.
[Recovery 88.2%, or 5.2% under the attenuation Charge.]

Rum produced.

Alcoholic Strength		38.6 o p.
Acidity	—	4.8
Ethers	—	70.4

EXPERIMENT 17.

Wash set up at 16.5 Brix.

Materials,	*A.*	*B.*
	320 lbs. Dunder (1)	320 lbs. Dunder (1)
	759 lbs. Cane Juice (2)	715 lbs. Cane Juice (4)
	7 lbs. Molasses (3)	9 lbs. Molasses (3)

(1) *Dunder.*

Brix	—	11.3
Sugars	—	0.6
Acidity	—	0.83

(2) *Cane Juice (A.) (D 95.)*

Brix	—	19.83
Total Sugars		

(3) *Molasses.*

Sugars	—	57.2

(4) *Cane Juice (B.) (D. 13.2)*

Total Sugars		16.13

Wash as set up.

		A.		B.
Brix	—	16.5	—	16.5
Acidity	—	0.35	—	0.39
Sugars	—	14.2	—	10.97

The difference between the Sugar content of the comparative Experiments is very striking. Although both were set up at the same gravity, one contains 14.2 of sugars while the other only 11.0 per cent.

The Cane Juice used in A. was from Seedling D. 95 in a very ripe and pure state with only 5% of non-Sugars in the total Solids, while B. was set up with impure juice from seedling D. 132 with 14 o/o of non-Sugars.

This is an illustration of the fallacious conclusions deducible from the use of the Saccharometer in Jamaica distilleries if no account of the Sugar content be kept.

A. The liquor attenuated to 1.9 Brix in 4 days, with a maximum temperature of 35.5° C.

The acidity rose from 0.35 to 0.53 ; attenuation 14.6 Brix.

The dead liquor only contained 0.049 o/o of Sugars and the Alcoholic strength was 13.57 o/o P.S. Charge on attenuation = 12.00 o/o P.S. Proof Spirit per degree attenuation=0.93. Yield of Alcohol on Sugars fermented=0.96 ; Acidity developed=0.18 o/o.

The Rum produced was as follows :

Alcoholic Strength		40.1 o.p.
Acids	—	12.0
Ethers	—	29.8

B. This liquor attenuated rather more quickly than A., and gave a final attenuation of 13.4 Brix.

The Acidity rose from 0.39 to 0.64 and the dead wash contained 12.2. o/o Proof Spirit. Charge on attenuation=11.14 o/o P.S.

Proof Spirit per degree Attenuation=0.91. Acidity developed =0.25 o/o. Only a trace of Sugar remained unfermented. Alcoholic yield from Sugar=1.11 P.S.

The Rum produced was as follows :

Alcoholic Strength		40.4 o.p.
Acids	—	9.6
Ethers	—	81.0

RESULTS OF DISTILLATION.

Charge.

Still=633 lbs=62.7 gallons.

		Lbs. Alcohol.
41 lbs. H. Wines @ 20.1	=	25.0
104 lbs. L. Wines @ 76.1 u.p.	=	11.4
Total Charge	=	36.4

Yield.

55 lbs. Rum @ 40.4 o.p.	=	40.5
27 lbs. H. Wines @ 16.3 o.p.	=	15.8
97 lbs. L. Wines @ 75.8 u.p.	=	10.8
Gross Yield	=	67.1
Deduct Charge	=	36.4
Nett Yield	=	30.7

Return

0.49 lbs. Alcohol per gallon
61.74 gallons Alcohol per 1,000 gallons
108.2 gallons P.S. per 1,000 gallons
77.8 gallons Rum 40 o.p. per 1,000 gallons
[Recovery 88.7 o/o or 2.0 o/o under 'charge.']

EXPERIMENT 18.

Wash set up at 15.5 Brix.

Materials

669 lbs. Cane Juice A.
382 lbs. Dunder B.
55 lbs. Molasses C.

A. Cane Juice.

Brix	13.8
Sugars	10.13

B. *Dunder.*

Brix	—	7.8
Sugars	—	0.21
Acidity	—	1.05

C. *Molasses.*

Sugars	—	57.2

The Liquor as set up was as follows:

Brix	—	15.5
Acidity	—	0.40
Sugars	—	9.26

It attenuated in four days to 2.3 Brix equal to an attenuation of 12 2 Brix. The Acidity rose from 0.40 to 0.53 per cent.

The maximum temperature recorded was 34° C.

No record of the Alcoholic content was obtained owing to an accident to the sample reserved for analysis.

The results of distillation were as follows:

Charge.

Still 564 lbs. = 56 gallons.

		Lbs. Alcohol.
32 lbs. H. Wines @ 6 o.p.	=	16.8
94 lbs. L. Wines @ 58.3 u.p.	=	18.2
Total Charge	=	35.0

Yield.

42.5 lbs. Rum = 41.4 o.p.	=	31.6
32.5 H. Wines @ 23.0 o.p.	=	20.3
88 lbs. L. Wines @ 74 1 u.p.	=	10.5
Gross Yield	=	62.4
Deduct Charge	=	35.0
Nett Yield	=	27.4

Return.

0.49 lbs. Alcohol per gallon
61.74 lbs. Alcohol per 1 000 gallons
108.2 lbs. P.S. per 1,000 gallons

[Recovered Proof Spirit per degree attenuation 0.839].
Attenuation charge = 10.9 o/o P.S.

Rum Produced.

Alcoholic Strength 41.4 o.p.

Ethers not determined.

Summary of Experiments on Initial Gravities.

1. The highest efficiency of alcoholic production is obtained at low settings of about 10 o/o sugars in the wash.

2. The largest recovery of rum per 1,000 gallons was obtained with liquor set up at 20 Brix with 16-17% sugars. In two experiments recoveries of 112.9 and 111.7 gallons of rum from 1,000 gallons wash were obtained or 4.7 and 3.5% respectively over the British Attenuation Charge of 1% p.s. for every five degrees of attenuation (i.e. for every reduction of 0.005 in specific gravity). Had the same amount of sugars, however, been set up at a standard of 10%, these experiments indicate that 25% more Rum would have been obtained.

3. Under the conditions obtaining in these experiments the production of alcohol rose from 1.00 p.s. per unit of sugars fermented at 20 Brix to 1.11 p.s. at 16.5 Brix. The liquors in every case died down with a mere trace of unfermented sugars only Thus, while the Proof Spirit obtained from 100 parts of sugars was only 76.8 at 22° Brix, it rose to 92.7 and 100 at 20 Brix, 107.7 at 17.5 Brix and 111.9 at 16.5 Brix.

4. The results of distillation were fairly good and in the case of the 20 Brix experiments decidedly good for a Jamaica Pot Still.

A Table of the comparative data is now given :—

COMPARATIVE DATA.

Brix.	Total Sugars	Sugars Fermented.	Proof Spirit %.	Percentage of efficiency of Alcoholic Production.	Attenuation Brix.	P. S. per deg. Attenuation Brix.	P. S. % Sugar Fermented.	Recovery Rum 40 o.p. per 1,000 gallons.	Percentage on Charge.
22	16.39	16.18	12.43*	68.3	15.2	0.818	76.8	80.3	95.5
20	16.6	16.5	15.3	82.4	17.0	0.909	92.7	112.9	104.7
20	17.05	17.0	17.0	89	18.0	0.940	100.0	111.7	103.5
17.5	13.6	13.55	14.6	96	15.5	0.940	107.7	83.1 (a) 87.4 (b)	94.8
16.5	14.2	14.15	13.6	85.5	14.6	0.930	96.1	—	—
16.5	11.0	10.9	12.2	99.4	13.4	0.910	111.9	77.3	97.1
15.5	9.26	9.2	—	—	12.9	—	—	77.3	99.7

* Too low.

Experiments with Sour Skimmings.

A gradational series was carried out to test the effect of using sour skimmings as an ingredient of the wash at four different gravities, viz :—22° B, 20°B, 19°B, 15.5 Brix, The results were as follows:

A —Wash Set up at 22° Brix.

Materials used

A. 872 lbs. Dunder
B. 586 lbs Cane Juice
C. 161 lbs. Molasses
D. 92 lbs. Skimmings

A. *Dunder.*

Brix	...	6.65
Acidity	—	1.36
Sugars	—	0.03

C. *Molasses.*

Brix	—	67.6
Total Sugars		66.6

D. *Skimmings.*

Brix	—	8.7
Sugars	..	1.39
Acidity	—	1.24

Wash as set up.

Brix	—	22.0
Sugars	—	15.63
Acidity	—	0.57
Alcohol	—	0.70

The wash died down in 5 days at 6.8 Brix with an attenuation of 15.2 Brix. The Acidity had increased to 0.95 and on standing for four days longer increased to 1.21.

The wash as distilled contained 1.54 % of sugar and 13.73 % of Proof Spirit. Attenuation Charge=13.1. Proof Spirit per degree attenuation 0.90. Acidity developed 0.64%. Yield of Alcohol upon Sugars=86.6% of theoretic maximum.

Distillation Results.

Charge.	Still 623 lbs.=90.6 gallons		Lbs. Alcohol
	100 lbs. L. Wines @ 81.5 u.p.	=	8.5
	28 lbs. H. Wines @ 8.3 o.p.	=	15.12
	Total Charge		23.62

Yield.

30 lbs. Rum @ 40.7 o.p.	=	22.16
30 lbs. H. Wines @ 23.5 o.p.	=	18.88
103 lbs. L. Wines @ 69.4 u p.	=	14.58
Gross Yield		55.62
Deduct Charge		23 62
Nett Yield		32.00

Return.

0.528 lbs. Alcohol per gallon
66.5 gallons Alcohol per 1,000 gallons
116 5 gallons Proof Spirit per 1,000 gallons.
83.2 gallons Rum o.p per 1,000 gallons
[Recovery 84.9 % or 11.1 % under Charge.]

Rum Produced.

Alcoholic Strength		40. o.p.
Acids	—	14 4
Ethers	—	126.7

B. Wash Set up at 20° Brix.

Materials Used.

(1) 400 lbs. Skimmings
(2) 400 lbs. Dunder
(3) 173 lbs. Molasses
65 lbs. Water.

(1) *Skimmings.*

Brix	—	3.8
Total Sugar		0.401
Acidity	—	0.39

(2) *Dunder.*

Brix	—	8.7
Total Sugar		0.42
Acidity	—	0.92

(3) *Molasses.*

Brix	—	70.8
Total Sugars		57.2

The Wash as Set up contained 12.12 o/o Sugar with an acidity of 0.49 o/o. After 10 days it attenuated to 9.6 Brix, equal to an attenuation of 10.4.

The temperature rose to its maximum of 27.5 C. on the third day and died at 21.5 C. The final Acidity was 0.9. The unfermented Sugar amounted to 1.13 o/o, and the Alcohol produced to 10.43 o/o P.S., equal to 1.003 per cent. Proof Spirit per degree Attenuation. 'Attenuation Charge' equals 8.96 o/o P.S. Yield of Alcohol on Sugar fermented=84.3 o/o of theoretic maximum.

DISTILLATION RESULTS.

Charge.

Still 563 lbs. Wash=54.4 gallons.

		Alcohol lbs.
29 lbs. High Wines @ 15.8 o.p.	=	15.91
97 lbs. Low Wines @ 82.1 u.p.	=	7.95
Total charge		23.86

Yield.

30.5 lbs. Rum @ 39 o.p.	=	22.18
31 lbs. H. Wines @ 9.8 o.p.	=	16.99
99 lbs. L. Wines @ 80.1 u.p.	=	9.05
Gross Yield	=	48.22
Deduct Charge	—	23.86
Nett Yield	=	24.36

Return.

0.447 lbs. Alcohol per gallon
56.32 gallons Alcohol per 1,000 gallons
98.7 gallons P.S. per 1,000 gallons
70.5 gallons Rum 40 o.p. per 1,000 gallons
[Recovery 94.6%, or 11 o/o over 'Charge.'

The Rum produced was as follows ;—

Alcoholic Strength		139 o/o P.S.
Acidity	—	67
Ethers	—	155

C. WASH SET UP AT 19° BRIX.

Materials.

(1) 264 lbs. Dunder.
(2) 139 lbs. Molasses.
(3) 176 lbs. Skimmings.
(4) 462 lbs. Cane Juice.

(1) *Dunder.*

Brix	—	7.8
Total Sugars		0.21
Acidity	—	1.05

(2) *Molasses.*

Brix	—	67.6
Total Sugars		66.6

(3) *Skimmings.*

Brix	—	8.7
Total Sugars		1.39
Acidity	—	1.24

(4) *Cane Juice.*

Total Sugars	10.5

The wash as set up at 19° Brix contained 15.8 o/o of Sugars with an acidity of 0.5 o/o

In 6 days the liquor had died down at 6.8 Brix with an acidity of 0.91. The Attenuation was 12.2 Brix. The dead wash contained 13.25 per cent of Alcohol as P. S. equal to 1.09 per degree Attenuation. The 'Charge' on Attenuation is 10.3 o/o P.S. Some Sugar (0.52 o/o) remained unfermented. The acidity developed equalled 0.38 o/o. Yield of Alcohol on Sugars fermented = 77% of Theoretical Maximum.

RESULTS OF DISTILLATION,

Spirit recovered = 0.503 lbs. Alcohol per gallon.
63.37 gallons Alcohol per 1,000 gallons.
111 08 gallons P.S. per 1,000 gallons.
79.3 gallons Rum 40 o.p. per 1,000 gallons.
[Recovery 83.8% or 8% over Charge.]

Rum Produced.

Alcoholic Strength		139.5 o/o P.S.
Acidity	—	21.6
Ethers	—	91.5

B. WASH SET UP AT 15.5 BRIX.

Materials.

191 lbs. Dunder
103 lbs. Molasses
251 lbs. Skimmings
535 lbs. Cane Juice (Sour)
30 lbs. Molasses Water.

Wash as set up.

Brix	—	15.5
Total Sugar		6.76
Acidity	—	0.62
Alcohol		?.

Wash died in 2 days with an Attenuation of 10° Brix and an increase of acidity equal to 0.13%.

The samples of Wash taken for analysis were unfortunately spoilt through inperfect preservation. From the Dunder it is estimated that the dead Wash contained 1.81% of unfermented Sugars. 'Charge' on Attenuation = 8.4% P.S. Materials had evidently fermented before being set up.

Results of Distillation.

Charge.

703 lbs. in Still=69 gallons.

		Lbs. Alcohol.
32.5 lbs. H. Wines @ 22.6 o.p.	=	20.3
88 lbs. L. Wines @ 74.1 u.p.	=	10.5
Total Charge		30.8

Yield.

52.5 lbs. Rum @ 40.9 o.p.	=	38.9
22.5 lbs. H. Wines @ 19.2 o.p.	=	13.6
100 lbs. L. Wines @ 63.9 o.p.	=	16.7
Gross Yield		69.2
Deduct Charge		30.8
Nett Yield	=	38.4

Return.

0.556 gallons Alcohol per gallon
70.05 gallons Alcohol per 1,000 gallons
122.76 gallons P.S. per 1,000 gallons.
87.7 gallons Rum 40 o.p per 1,000 gallons.

Rum Produced.

Alcoholic Strength		40.9 o.p.
Acidity	—	16.8
Ethers	—	123

Dunder Series.

A series of 16 experiments was carried out to test (a) the effect of using Dunder of various concentrations and (b) the comparative results from using our own dunder and that from a typical Westmoreland distillery (Mesopotamia.)

Dunder was used at various concentrations from 23.6 Brix to a minimum of 10.0 Brix, The results of the individual experiments are now given :—

A. Dunder at 23.6 Brix.

Materials.

(1). 434 lbs. Dunder at 23.6 Brix.
(2). 319 lbs. Cane Juice.
(3). 39 lbs. Molasses.
(4). 300 lbs. Skimmings.

(1) *Dunder.*

Brix	—	23.6
Total Sugars		1.81
Acidity	—	1.75

(2) *Cane Juice.*

Brix	—	17.6
Total Sugars		15.15
Acidity	—	0.24

(3) *Molasses.*

Brix	—	67.6
Total Sugars		66.6

(4) *Skimmings.*

Brix	—	8.7
Total Sugars		1.0
Acidity	—	1.36

Liquor as set up.

Brix	—	20.0
Acidity	—	0.95 o/o
Total Sugars		8.1 o/o

The liquid attenuated in 8 days 9.1° Brix to 10.9°.

The dead Wash contained 0.52 Sugars, 1.24 o/o Acids and 9.1 o/o Alcohol as Proof Spirit. The 'Charge' on Attenuation would be 7.87 o/o P.S.

RESULT OF DISTILLATION.

1 gallon yielded 0.293 lbs. Alcohol.
1,000 gallons yielded 37.52 gallons Alcohol
1,000 gallons yielded 65.75 gallons P. S.
1,000 gallons yielded 47 gallons Rum 40 o.p.

This result was obtained on a small charge, about ⅓ only of the ordinary charge for the Still and is clearly abnormal.

Rum Produced.

Alcoholic Strength		138,2 o/o P. S.
Acidity	—	12.5
Ethers	—	172.5

Dunder Produced.

Brix	—	16.0
Total Sugars		0.78
Acidity	—	1.55

B. DUNDER AT 20° BRIX.

EXPERIMENT 1.

Materials used.

(1). 434 lbs. Dunder 20.2 Brix.
(2). 425 lbs. Cane Juice.
(3). 176 lbs. Skimmings.
(4). 78 lbs. Molasses.

Composition of Materials.

(1) *Dunder.*

Brix	—	20.2
Total Sugars		2.96
Acidity	—	1.54

(2) *Cane Juice.*

Brix	—	19.3
Total Sugars		17.0

(3) *Skimmings.*

Brix	—	8.65
Total Sugars		5.26
Acidity	—	0.69

(4) *Molasses.*

Brix	—	67.6
Total Sugars		66.6

The Wash as set up was as follows :—

Brix	—	20.0
Total Sugars		13.6 o/o
Acidity	—	0.67

In four days the liquor attenuated to 8.0 Brix with an Acidity of 0.78 o/o and a content of 12.03 o/o Alcohol as Proof Spirit. The Charge on Attenuation would amount to 10.2 o/o P.S. The unfermented Sugar amounted to 1.5 o/o. Proof Spirit per degree Attenuation=1.002.

Results of Distillation.

63.5 gallons Alcohol per 1,000 gallons.
111.3 gallons P. S. per 1,000 gallons.
79.5 gallons Rum 40 o.p. per 1,000 gallons.
Recovery 92.5 o/o or 9.1 o/o over Charge.

Rum Produced.

Alcoholic Strength		43 o.p.
Acidity	—	16.8
Ethers	—	63

Experiment 2. Dunder at 20.0 Brix.

Materials.

(a.) 418 lbs. Dunder at 20° Brix.
(b.) 414 lbs. Cane Juice.
(c.) 304 lbs. Skimmings.
(d.) 51½ lbs. Molasses.

(a.) *Dunder.*

Brix	—	20.0
Sugars	—	2.87
Acidity	—	1.6

(b.) *Cane Juice.*

Brix	—	20.0
Sugars	—	18.5

(c.) *Skimmings*

Brix	—	9.4
Sugars	—	2.7
Acidity	—	0.75

(d.) *Molasses*

Total Sugars	71.4

Wash as set up.

Brix	—	19.2
Total Sugars		11.5
Acidity	—	0.75

The liquor attenuated in 7 days to 8.4 Brix = 10,8 attenuation. After a further five days, an attenuation of 110, Brix was obtained with a final acidity of 0,95

The Wash as distilled contained 10.13 o/o of Proof Spirit and 1.1 o/o of unfermented Sugar. P. S. per degree attenuation = 0.92

RESULTS OF DISTILLATION.

55.3 gallons Alcohol per 1,000 gallons.
96.9 gallons P. S. per gallons.
69.2 gallons Rum 40 o/o per gallons.
Recovery = 95.6 o/o or 4.8 o/o over 'charge'

Rum Produced.

Alcoholic Strength	137.5 P. S.
Acidity.	28.8
Ethers.	179.5

EXPERIMENT 3. DUNDER AT 20.0 BRIX.

Materials.

(a) 418 lbs. Dunder at 20.9 Brix.
(b) 631 lbs. Cane Juice.
(c) 37 lbs. Molasses.

No Skimmings were used.

(a.) *Dunder.*

Brix	—	20.9
Acidity	—	1.7
Sugars	—	2.12

(b) *Cane Juice.*

Sugars	—	14.5

(c.) *Molasses.*

Sugars	—	71.4

The Wash as set up was as follows :

Brix	—	19.0
Sugars	—	11.0
Acidity	—	0.50

The liquor attenuated in 2½ days to 6.5 Brix with an Acidity of 0.57 o/o and contained 11.62 o/o Alcohol as Proof Spirit.

The Sugar unfermented was 0.19 o/o. The 'charge' on Attenuation Equals 10,6 o/o of Proof Spirit.

Proof Spirit per degree attenuation 0.93.

RESULTS OF DISTILLATION.

51.8 gallons Alcohol per 1,000 gallons
90.75 gallons P.S. per 1,000 gallons
64.2 gallons Rum 40 o p. per 1,000 gallons
Recovery 78 o/o, 14.4 under charge.

Rum Produced.

Alcoholic Strength		140.5 p.s.
Acidity	—	19.2
Ethers	—	105.6

C. DUNDER AT 19° Brix.

Materials.

A. 434 lbs. Dunder
B. 482 lbs. Cane Juice
C. 61 lbs. Molasses
D. 230 lbs. Skimmings

A—*Dunder,*

Brix	—	19.15
Sugars	—	1.61
Acidity	—	1.55

B—*Cane Juice.*

Sugars	—	17.5

C—*Molasses,*

Sugars	—	66.6

D—*Skimmings.*

Brix	—	12.6
Acidity	—	0.56
Sugars	—	10.64

The Wash as set up was as follows: —

Brix	—	20.0
Acidity	—	0.59
Sugars	—	13.3 o/o

In two and a half days the liquid had died down to a gravity of 6.6 Brix indicating an Attenuation of 13.4. The Wash was not distilled until 4 days after the attenuation had ceased, whereby the Acidity increased from 0.77 to 0.85 o/o.

The Wash as distilled contained 0.68 o/o of unfermented Sugars and 12.7 o/o of Proof Spirit. Charge on Attenuation 11.4 o/o P.S. Proof Spirit per degree Attenuation 0.955.

RESULTS OF DISTILLATION.

Per 1,000 gallons distilled
68.16 gallons Alcohol
119.4 gallons P S.
85.3 gallons Rum 40 o.p.

Recovery. 4 7 o/o over Charge on Attenuation, and 94 o/o of total spirit in Wash.

Rum Produced.

Alcoholic Strength		143.0 p.s.
Acidity	—	16.8
Ethers	—	63.4

D. DUNDER AT 15 BRIX.

EXPERIMENT 1.

Materials.

A. 434 lbs. Dunder
B. 430 lbs. Cane Juice
C. 197 lbs. Skimmings
D. 105 lbs. Molasses

A. *Dunder.*

Brix	—	15.0
Total Sugars		0.95%
Acidity	—	1.6%

B. *Cane Juice.*

Sugars	—	16.39%

C. *Skimmings.*

Sugars	—	5.26%
Acidity	—	0.69 o/o

D. *Molasses.*

Sugars	—	66.6%

The Wash as set up was as follows :—

Brix	—	20.0
Sugars	—	13.84
Acidity	—	0.50

In 3 days the liquor died at 9.2 Brix with an attenuation of 10.8 The liquor stood for two days longer during which time the acidity increased 0.24 o/o to 1.15. The Wash as distilled contained 11.2 o/o of P.S. and 0.07 o/o Sugars remained unfermented. The charge on Attenuation amounts to 9.29 o/o Proof Spirit.

Distillation Results.

58.33 gallons Alcohol from 1,000 gallons.
102.2 gallons P.S. from 1,000 gallons.
73.0 gallons Rum 40 o.p. from 1,000 gallons.

Recovery 91.25 o/o or 11 o/o over 'Charge on Attenuation.'

Rum Produced,

Alcoholic Strength		140.6 P.S.
Acidity	—	9.6
Ethers	—	102.8

D. Dunder at 15° Brix.

Experiment 2.

Materials.

(a) 400 lbs. Dunder
(b) 300 lbs. Cane Juice
(c) 442 lbs. Skimmings
(d) 136 lbs. Molasses

(a) *Dunder.*

Brix	—	15.0
Sugars	—	0.50 o/o
Acidity	—	1.92 o/o

(b) *Cane Juice.*

Sugars	—	15.0 o/o

(c) *Skimmings.*

Sugars	—	1.72 o/o
Acidity	—	0.82 o/o

(d) *Molasses.*

Sugars	—	71.4 o/o

The Wash as set up was as follows :—

Brix	—	19.0
Sugars	—	12.5 o/o
Acidity	—	0.86

In 6 days the liquor had attenuated to 9.8 Brix with an Acidity of 1.29. It was left for 4 days before being distilled, the final product sent to the Still being as follows :—

Brix	—	9.6
Attenuation		9.4
Acidity	—	1.46
Alcohol	—	11.08 P.S.
Unfermented Sugars		1.24

RESULTS OF DISTILLATION.

Per 1,000 gallons distilled
62.36 gallons Alcohol
109.3 gallons P.S.
78.1 gallons Rum 40 o.p.
Charge on attenuation 80.7 gallons p.s.
Recovery 98.6 o/o

Rum Produced.

Alcoholic Strength		140.5 p.s.
Acidity	—	26.4
Ethers	—	211.2

E. DUNDER AT 10° BRIX.

EXPERIMENT 1.

Materials.

A. 434 lbs. Dunder
B. 519 lbs. Cane Juice
C. 105 lbs. Molasses
No Skimmings.

A—Dunder.

Brix	—	10.0
Sugars	—	0.72
Acidity	—	1.35

B—Cane Juice.

Sugars	—	16.13

C—Molasses.

Sugars	—	66.6

The wash as set up was as follows :

Brix	—	20.0
Total Sugars		15.4
Acidity	—	0.63
Alcohol	—	0.12

After 4 days it attenuated to 3.3 Brix, attenuation = 16.7, with an acidity of 0.73 and 15.0 of Proof Spirit.

The Sugar remained unfermented was 0.41 per cent. Proof Spirit per degree Attenuation 0.90.

The Charge on attenuation is 14.07 to which the orginal alcohol in the liquid as set up must be added, bringing it to 14.2 per cent P.S.

RESULTS OF DISTILLATION.

Yield per 1,000 gallons Wash.

75.3 gallons Alcohol
132.0 gallons P.S.
94.3 gallons Rum 40 o.p.
Recovery 88 per cent., or 7 o/o under charge on attenuation.

Rum Produced.

Alcoholic Strength	139.4 P.S.
Acidity	4.8
Ethers	77.4

E. DUNDER AT 10° BRIX.

EXPERIMENT 2.

Materials

(a.) 400 lbs. Dunder
(b.) 711 lbs. Cane Juice
(c.) 71 lbs. Molasses.

(a) *Dunder.*

Brix —	10.45
Total Sugar	0.62
Acidity —	1.27

(b) *Cane Juice.*

Total Sugars	16.67

(c) *Molasses.*

Total Sugars	71.4

Wash as set up.

Brix —	19.0
Total Sugars	15.
Acidity —	0.42

In three days the Wash attenuated 15.6 Brix to 3.4. It was left for four days before being distilled during which time the acidity increased from 0.54 to 07.6 o/o. The Wash as distilled contained 0.25 per cent. of unfermented Sugars and 14.2 per cent. of Proof Spirit.

RESULTS OF DISTILLATION.

Charge of Still 57.2 gallons.
Retorts 34.38 lbs. Alcohol.

Recovery..

Rum	—	38.00 lbs. Alcohol
H. Wines	—	17.35 lbs. ,,
L. Wines	—	7.47 lbs. ,,
Total		62.8
Deduct Charge		34.38
Nett Yield		28.44 lbs. Alcohol.

Yield per 1,000 gallons Wash.

62.6 gallons Alcohol
109.7 gallons P.S.
78.4 gallons Rum at 40 o.p.

Recovery 77 o/o of Alcohol in the liquor at 15.6 o o under Charge on Attenuation.

A poor result from the Still.

Rum Produced.

Alcohol Strength		140.6 P.S.
Acidity	—	14.4
Ethers	—	119.7.

SUMMARY OF DUNDER EXPERIMENTS.

Brix of Dunder.	Sugars Fermented.	Sugars Unfermented.	Alcoholic Yield per 1,000 gallons.	Rum Recovered per 1,000 gallons.	Ethers in Rum.
23.6	7.6	0.5	91.0 galls. P.S.	47 gallons	173.5
20.0	12.1	1.5	120.3	79.5	63.
20.0	10.4	1.1	101.3	69.2	179.5
20.0	11.6	0.2	116.2	64.3	105.6
19.0	12.6	0.7	127.0	85.3	63.4
15.0	13.1	0.7	112.0	73.0	102.8
15.0	11.3	1.2	110.8	78.1	211.2
10.0	15.0	0.4	150.0	94.3	77.4
10.0	14.75	0.25	142.0	78.4	119.7

EXPERIMENTS WITH WESTMORELAND DUNDER.

Through the kindness of Mr. Percival H. Greg of Mesopotamia a supply of Westmoreland Dunder was obtained with which three Experiments were carried out.

WESTMORELAND DUNDER No. 1.

Materials.

A. 400 lbs. Dunder.
B. 409 lbs. Cane juice.
C. 316 lbs. Skimmings.
D. 19 lbs. Molasses.

A. *Dunder.*

Brix —	15.2
Total Sugars	2.36
Acidity —	2.35

B. *Cane Juice*

Total Sugars	19.23

C. *Skimmings.*

Total Sugars	1.68
Acidity —	0.75

D. *Molasses*

Total Sugars	6.66

Wash as set up.

Brix —	19.0
Total Sugars	13.05
Acidity —	0.95

The liquor attenuated to 6.1 Brix in four days with an Acidity of 1.16. During the three following days fermentation still persisted and the liquor finally died at 6.1 Brix with an acidity of 1.23. The dead liquor contained 0.63 o/o of unfermented Sugars and 12.06 per cent. of Proof Spirit.

The charge on attenuation amounts to 10.9 o/o p.s. Proof Spirit per degree attenuation=0.332. Acidity developed 0.28 per cent. Efficiency of Alcoholic production on Sugar fermented 86 o/o

WESTMORELAND DUNDER.

EXPERIMENT 2.

Materials.

(a.) 300 lbs. Dunder
(b.) 831 lbs. Cane Juice
(c.) 55 lbs. Molasses.

No Skimmings were used in this Experiment.

A. Dunder.

Brix —	15.2
Total Sugars	0.67
Acidity —	2.38

(b.) *Cane Juice.*

Total Sugars	18.2

(c.) *Molasses.*

Total Sugars	66.6

Wash as set up.

Brix	—	19.0
Total Sugars		16.17
Acidity	—	0.55

In four days the liquor attenuated 16.2° Brix, with an Acidity of 0.78. The dead liquor contained 0.2 Sugars only and the Alcoholic content equalled 14.04 per cent. of Proof Spirit. This indicates an efficiency of 77.2 per cent. in Alcoholic production from the Sugars fermented. The Charge on Attenuation is 13.6 o/o P.S.

Proof Spirit per degree Attenuation 0.866.

WESTMORELAND DUNDER.

EXPERIMENT 3.

Materials.

(a.) 292 lbs. Dunder
(b.) 638 lbs. Cane Juice.
(c.) 40 lbs. Molasses

(a) *Dunder.*

Brix	—	15.2
Total Sugars		0.67
Acidity	—	2.38

(b) *Cane Juice.*

Total Sugars	19.23

(c) *Molasses.*

Total Sugars	6.66

Wash as set up.

Brix	—	19.0
Total Sugars		15.8
Acidity	—	0.60

The wash died down in 4 days to 3.4 Brix with an Acidity of 0.85. The wash as distilled contained 0.28 of sugars and 12.6 per cent. of Proof Spirit. This represents an efficiency of 72.4 in Alcohol

production. The charge on attenuation demands 13.1 o/o of Proof Spirit. Proof Spirit produced per degree attenuation equals 0.80 o/o

There is therefore reason to conclude that the analytical figure of 12.6 o/o P.S. in the dead liquor is incorrect and that the true Alcoholic Content of the liquor as sent to the Still was in Excess on this amount.

The rums produced from these experiments with Westmoreland dunder were low in Ethers 77, 77.4 and 77.4 in the three series respectively. The conclusion drawn from these results was that the mere fact of utilising the dunder derived from another distillery would not appreciably affect the rum producible from materials fermented in the usual way.

Part V.

Report on the Manufacture of Jamaica Rum by Charles Allan, B.Sc., Fermentation Chemist.

As a preliminary to investigating the conditions of rum manufacture I visited in the end of 1903, and during 1904, a number of estates as representing the manufacture of the various grades of rum produced in the Island. I spent December 1903 at Cinnamon Hill in St. James and the following January at Denbigh Estate in Clarendon. On those estates I made myself acquainted with the process of making what is called "Common Clean" rum. In February I went to Trelawny, and making Cambridge Estate my headquarters I endeavoured to become familiar with the methods adopted in the manufacture of Flavoured Rum.

Afterwards I made short visits to the estates in Westmoreland, St. Catherine and St. Ann.

From those visits I learned the methods followed on the estates and obtained a general idea of the problems which had to be faced in making such an investigation as I had undertaken.

The first and one of the most interesting problems which had to be solved was what constituted the difference between Common Clean rum and the high flavoured rum known as 'German Rum.'

The prevailing idea seemed to be that the flavour of those rums was due to the essential oils in the cane, and the fact was put forward as supporting this theory that all estates, with one exception, which had been successful in producing this class of rum, were northside estates and ratooning estates.

On comparing the methods of manufacturing Common Clean and High Flavoured Rum one could not but come to the conclusion that either the round about process used in making High Flavoured rum was unnecessary, or the theory that the Flavour was due to the essential oils in the cane was at fault.

On returning from visiting the estates two samples of rum were sent to me to the laboratory from a northside estate with the request that I should find out by analysis the difference between the samples, as one sample had fetched a considerably higher price than the other. The sample of higher value was from the 1904 crop, the other sample from the previous crop and was an average of what the estate had formerly produced.

The analyses which were interesting and have proved of considerable importance were :—

Sample	In parts per 100,000 of absolute alcohol.				Alcoholic Strength.
	Ethers.	Acidity.	Aldehydes.	Furfurol.	
1903	344.9	21.6	11.5	.45	38 % O.P.
1904	510 4	36.0	10.0	.31	38 % O.P.

The only marked difference in the analyses of these samples was in the compound ethers and in the acidity. It seemed highly probable, therefore, that the enchanced value of the 1904 sample was due to the increase in the compound ethers which amounted to 165.5 parts per 100,000 of absolute alcohol.

Analyses of a large number of rum samples were made and a comparison of the data will clearly show the flavoured rums have a much higher compound ether content.

Parish.	Per 100,000 parts abs. Alcohol.	
	Ethers as Ethyl Acetate.	Acidity as Acetic Acid.
St. Andrew	287.0	50.2
"	269.0	47.4
"	229.2	277.5
"	224.0	81.3
St. Ann	968.0	7.2
St. Catherine	269.0	53.0
"	269.6	29.03
Clarendon	271.1	55.7
"	228.2	29.1
"	196.0	4.0
"	238.5	18.6
"	352.0	24.0
"	517.44	4.8
"	327.36	19.20
"	269.8	17.3
"	286.5	32.8
"	242.08	7.2
"	299.2	9.60
"	1,056.0	12.0
St. Elizabeth	204.16	9.60
Trelawny	792.0	28.8
"	959.2	24.0
"	1,320.0	44.4
"	1,020.8	14.4
"	674.46	43.9
"	1,267.2	31.2
"	1,302.4	7.2
"	1,417.6	24.0
"	302.72	21.6
"	415.36	12.0
"	281.6	8.4
"	985.6	16.8
"	862.4	48.0
"	1,126.4	9.6
"	1,091.2	14.4

Parish.	Per 100,000 parts abs. Alcohol.	
	Ethers as Ethyl Acetate.	Acidity as Acetic Acid.
Tielaway (*Continued*).	985.6	9 6
"	1,284.8	12.0
"	520.96	28.8
"	1,073.6	14.4
"	1,408.6	4.8
St. James.	582.5	55.7
"	339.6	50.9
"	773.0	94.2
"	1,462.0	169.01
"	862 0	28.8
"	344.96	21.6
"	510.4	36.0
"	492.8	31.2
"	580.8	31.2
Westmoreland.	292.16	21.6
"	289.2	16.9
"	214.4	8.4
"	632.6	10.4
"	455.3	17.0
"	506.9	11.5
"	360.1	27.5
"	299 2	27.0
"	398.7	20.7
"	373.0	26.9
"	524.0	6.7
"	398.2	5.8
"	519.9	7.7
"	220.5	36.5
"	389.7	48.8
"	656.5	20.7
"	456.5	29.17
"	453.0	10.4
"	373.46	19.0
"	205.0	16.0
"	401.28	32.89

From the above list the very high Ether content is more striking, but the variation from the lowest to the highest is the most noteworthy feature.

Taking a general view of the rums produced in the Island, as grouped under the different parishes, it will be observed that the parishes which are noted for the high priced rums lead easily in the amount of Ethers produced.

Trelawny comes first while Westmoreland is second.

High Ether rums are not confined to any one parish but, without exception, wherever a rum is found which contains over 1,000 parts of Ethers that rum invariably commands a high price in the market.

The evident conclusion is that a high Ether content is an essential feature on high priced rums. It does not follow that the quantitative amount of Ethers alone determine the value of the rum. The proportions in which the various Ethers are blended is a most important factor.

How this large amount of Ethers is produced and why it could be produced on some estates and not on others next engage our attention. A comparison of the method of manufacture and an examination of the materials used in the distilleries are instructive.

On estates making 'common clean' rum the method adopted is simplicity itself when compared with the complicated manipulation required for making high flavoured rums.

The 'Common Clean' process consists in general terms in mixing together dunder. molasses and skimmings in proportions which are considered in the experience of the distiller to give best results. There are many exceptions to this simple formula. Some allow the skimmings to stand in tanks and so become sour, while others use what is termed trash cisterns. These cisterns are filled with cane trash and the skimmings are run on to this and allowed to soak through These devices have all the same end in view namely the production of acid.

The gravities of the wash as set up vary within wide limits, but are generally lower than those used in making flavoured rum. The time taken for the wash to ferment is much less in making common clean than flavoured rum.

A general outline of the process of manufacturing flavoured rum is as follows :—

The wash is set up with skimmings, dunder, molasses, acid and flavour.

Acid is made by fermenting rum cane juice which has been warmed in the coppers. To this juice is added dunder and sometimes a little skimmings. When fermentation is about over the fermented liquor is pumped on to cane trash in cisterns and here it gets sour. Into these cisterns sludge settling from the fermented

wash is from time to time put. This acid when considered fit for use smells like sour beer. Flavour is prepared by running fermented rum cane juice into cisterns outside the fermenting house along with cane trash and dunder which has been stored from the former crop. Generally a proportion of liquid from what is called the 'muck hole' is also added to this cistern. The components of the 'muck hole' are the thicker portion of the dunder from the Still, the lees from the retorts and cane trash and other adventitious matter which from time to time finds its way into this receptacle. From this cistern the incipient flavouring material passes on to a second and third cistern filled with cane trash and to which sludge from fermented wash has been added. From the third cistern it is added to the wash. Skimmings are run from the boiling-house into cisterns half filled with cane trash. This is allowed to remain for 4, 5 or 6 days. When the skimmings are considered ripe, the wash is set up with them. Fermentation lasts 7 to 8 days. The time which elapses between setting up the wash and distillation is from 13 to 14 days

As in the case of the common clean process there are many modifications introduced by the distiller, but the foregoing holds good as a general description.

A comparison of the analytical data of distillery materials brings out a very noticeable difference in the amount of acid produced by the two processes.

A 1—FERMENTATION PRODUCTS SERIES I. COMMON CLEAN RUM.

Results expressed as lbs. per 10 gallons or "Liquid Per Cent."

No.	Description.	Brix % by Weight.	Sucrose.	Glucose.	Total Sugars.	Total Acids as Sulphuric.	Vol. Acids as Sulphuric.	Alcohol as P. S. o/o
	Wash just set up ...	16.2	4.80	2.22	8.27	1.37	0.38	2.56
6	Skimmings ...	15.6	0.55	2.50	3.08	1.03	0.32	Trace
6	Dunder A. ...	15.0	—	0.30	0.30	2.21	.49	—
63	Molasses. ...	69.8	52.15	11.76	66.66	0.10	—	—
78	Dunder B ...	13.85	—	—	—	2.07	0.30	—
79	Dead Liquor ...	8.8	0.17	—	0.18	1.53	.235	10.28

A 2.—FERMENTATION PRODUCTS. SERIES I. B.

Results as lbs. per 10 gallons or "Liquid Per Cent."

Ref. No.	Description.	Brix lbs. per 10 lbs.	Glucose.	Sucrose.	Total Sugars.	Total Acids as Sulphuric.	Vol. Acids. as Sulphuric.	Alcohol as P. S. o/o.
133	Cane Juice ...	16.0	1.16	11.93	13.72	.25	.01	—
134	Dunder ...	15.02	1.35	—	1.35	1.62	.27	—
135	Unfermented Wash ...	20.00	—	—	12.92	1.90	.15	—
136	Fermented Wash ...	7.30	—	—	.82	1.27	.26	12.78
137	Rum (Turbid) ...	32.0 Over Proof.	—	—	—	0.2	—	—

A 3—FERMENTATION PRODUCTS. SERIES 1 C

Result as lbs. per 10 gallons or "Liquid Per Cent.

Ref. No.	Description.	Brix lbs. per 10 lbs.	Glucose.	Sucrose.	Total Sugar Inverted.	Total Acidity as Sulphuric.	Volatile Acidity as Sulphuric.	Alcohol as P. S. o/o.
126	Dunder	13.20	—	—	0.95	1.67	0.22	0.48
127	Dead Wash	6.10	—	—	0.86	1.18	0.22	13.52
128	Cane Juice from Mill	14.60	2.47	6.50	9.31	0.43	0.60	—
129	Boiler Liquor	24.95	4.83	17.17	22.80	0.49	0.12	—
130	Unfermented Wash	20.50	—	—	13.50	1.13	0.19	—

Showing German Flavoured Rum.

Results in lbs. per 10 gallons = Liquid Per Cent.

No.	Descriptions.	Brix lbs. per 10 lbs.	Glucose.	Total Sugars.	Total Acidity as Sulphuric.	Volatile Acidity as Sulphuric	Alcohol as P. S. o/o.
	Dead Wash	13.50	—	0.79	3.66	0.55	10.78
92	Acid	5.65	—	0.30	2.50	0.40	6.75
100	Skimmings	15.36	—	5.10	2.16	0.54	—
101	Flavour	17.18	—	0.39	2.25	0.51	2.82
102	Dead Wash Bottoms ...	15.95	—	0.94	3.33	0.68	0.76
103	Molasses	69.24	13.33	44.87	—	—	0.90
104	High Wines	—	—	—	0.15	—	119.80
105	Low Wines	—	—	—	0.50	—	27.50
114	Rum	—	—	—	0.03	—	—

A 5—FERMENTATION PRODUCTS. SERIES II. B.

Northside German Flavoured Rum.

Result in lbs. per 10 gallons " Liquid Per Cent.

Ref. No.	Description.	Brix lbs. per 10 lbs.	Glucose.	Total Sugars.	Acidity Total as Sulphuric.	Volatile Acidity as Sulphuric.	Alcohol as P. S. o/o.
106	Dunder	23.50	—	1.54	2.40	.98	—
107	Acid	6.65	—	0.36	4.50	.75	.92
108	Flavour	8.90	—	0.20	2.70	.80	.76
109	Skimmings	13.20	—	0.40	2.45	.45	2.08

A 3—FERMENTATION PRODUCTS. SERIES III.

West End Medium Rum.

Result as lbs. per 10 gallons or "Liquid Percentage.

Ref. No.	Description.	Brix o/o by weight.	Total Sugars Inverted.	Total Acids as Sulphuric.	Volatile Acids as Sulphuric.	Alcohol as P. S. o/o.
95	Fermented Wash A. ...	8.10	0.76	1.37	0.27	14.32
96	Skimmings ...	12.50	0.72	1.72	0.33	0.22
97	Fermented Wash B. ...	5.95	0.40	1.57	0.27	14.58

A.—FERMENTATION PRODUCTS.—SERIES IV.

NORTHSIDE MEDIUM RUM.

Result expressed as lbs. per 10 gallons or "Liquid Per Cent."

Description.	Brix By Weight.	Glucose.	Sucrose.	Total Sugars.	Total Acids as Sulphuric.	Volatile Acids as Sulphuric.	Total Solids by Evaporation.	Alcohol as Proof Spirit Per Cent.
Rum Cane Juice ...	10.35	2.2	5.82	8.33	—	—	—	—
Dunder ...	—	.20	.14	.36	1.74	.17	13.13	—
Molasses ...	70.4	22.50	31.395	55.55	—	—	—	—
Liquid from Trash Cistern ...	—	1.22	2.14	3.57	1.17	.09	8.42	7.47
Cane Juice untempered	14.65	1.25	10.69	12.50	—	—	—	—
Fermented Liquor ...	9.91	.625	.36	1.00	.17	—	9.40	2.4
Cane Juice Tempered..	13.76	1.30	11.69	13.60	.05	—	—	—
Dunder ...	—	.78	—	.78	1.67	.15	8.84	—
Liquor from Trash Cistern ...	—	.33	—	.50	—	—	3.84	2.01
Molasses ...	77.36	22.0	34.14	64.91	—	—	—	—

A 2.—FERMENTATION PRODUCTS. SERIES V. MEDIUM RUM

Results as lbs. per 10 gallons or "Liquid Per Cent."

Ref. No.	Description.	Brix lbs. per 10 lbs.	Glucose.	Sucrose.	Total Sugars.	Total Acids as Sulphuric.	Vol. Acids as Sulphuric.	Alcohol as P. S. o/o.
68	Cane Juice ...	18.29	1.65	13.61	15.38	0.30	0.06	—
69	Unfermented Liquor ...	18.45	2.10	6.54	8.88	1.47	0.15	6.64
70	Dead Liquor ...	4.90	0.21	—	0.21	1.32	0.27	14.04
71	Molasses ...	83.30	19.23	61.59	76.80	0.49	0.22	0.92
72	Lees ...	—	—	—	—	0.06	0.06	12.25
90	Molasses (lime used for clarification) ...	77.24	18.52	41.80	62.50	0.20	—	—
91	Skimmings ...	7.77	2.35	0.68	3.08	0.44	0.08	3.26
92	Dunder ...	17.95	0.03	—	0.03	2.04	0.04	0.70
84	Molasses. No lime used for clarification ...	71.56	21.26	21.26	66.66	—	—	—

FERMENTATION PRODUCTS.

Nos.	Description.	Brix.	Total Sugars.	Total Acidity as Sulphuric.	Volatile Acidity	Alcohol as P.S. o/o
1	Cane Juice tempered. ...	16.96	15.28	...	...	...
2	Skimmings (Fresh) ...	17.76	3.13	0.098	...	...
3	Molasses ...	68.80	61.54	...	...	...
4	Dunder ...	18.19	0.14	3.33	0.186	...
5	Dunder (old last year) ...	23.88	0.19	3.185	0.282	0.7
6	Rum Cane Juice (fermented) ...	4.33	0.40	2.60	0.307	8.54
7	Acid, No. 2 Cistern ...	5.06	0.50	2.60	0.360	7.08
8	Dead Liquor ...	10.02	0.46	2.45	0.300	13.52
9	Skimmings and Dunder (no flavour) ...	17.74	4.12	2.245	0.260	4.72
10	Liquor with acid ...	22.27	3.63	1.813	0.210	...
11	Dead Wash Bottom ...	10.53	0.235	4.70	0.31	14.32
12	Acid ready for use ...	5.60	0.424	2.45	0.68	...
13	Skimmings ready for use ...	12.97	1.25	2.74	0.46	...

Molasses.

Glucose	—	10.87 o/o
Sucrose	—	38.39 o/o
Total Sugars	—	51.28 o/o
Glucose	—	12.00 o/o
Sucrose	—	33.25 o/o
Total sugars	—	47.00 o/o
Brix	—	70.00 o/o
Glucose	—	11.11 o/o
Sucrose	—	51.10 o/o
Total sugars	—	64.30 o/o
Brix	—	69.90 o/o
Glucose	—	11.76 o/o
Sucrose	—	52.15 o/o
Total sugars	—	66 66 o/o
Brix	—	70.10 o/o
Glucose	—	4.34 o/o
Sucrose	—	54.43 o/o
Total sugars	—	—
Brix	—	48.17 o/o
Glucore	—	12.50 o/o
Sucrose	—	29.69 o/o
Total	—	43 75 o/o
Brix	—	77.36 o/o
Glucose	—	29.00 o/o
Sucrose	—	34.14 o/o
Total sugars	—	64.94 o/o
Brix	—	83.30 o/o
Glucose	—	19.23 o/o
Sucrose	—	54.69 o/o
Total sugars	—	76.80 o/o
Brix	—	71.56 o/o
Glucose	—	21.26 o/o
Sucrose	—	43.13 o/o
Total sugars	—	66.66 o/o
Brix	—	71.24 o/o
Glucose	—	18.52 o/o
Sucrose	—	41.80 o/o
Total sugars	—	62.50 o/o
Glucose	—	14.28 o/o
Sucrose	—	49.76 o/o
Total sugars	—	66.60 o/o

MOLASSES, continued.

A. I.

Brix	—	83.90 o/o
Glucose	—	16.94 o/o
Sucrose	—	45.59 o/o
Total sugars	—	64.93 o/o

A. I. x.

Brix	—	84.83 o/o
Glucose	—	18.86 o/o
Sucrose	—	41.46 o/o
Total sugars	—	62.50 o/o

Brix	—	69.80 o/o
Glucose	—	7.40 o/o
Sucrose	—	52.34 o/o
Total sugars	—	62.50 o/o

Brix	—	69.24 o/o
Glucase	—	13.33 o/o
Sucrose	—	44.87 o/o
Total sugars	—	60.56 o/o

Brix	—	78.32 o/o
Glucose	—	20.83 o/o
Sucrose	—	36.75 o/o
Total sugars	—	59.51 o/o

Brix	—	68 60 o/o
Glucose	—	5.33 o/o
Sucrose	—	59.39 o/o
Total sugars	—	61.54 o/o

The analyses of these Fermentation Products from Jamaica distilleries were made by Mr. A. SIME, late Assistant Chemist to the Experiment Station.

A very large preponderance of the total ethers in rum is acetic ether but as this adds but little or no flavour, the real aroma of rum must be due to the other ethers such as Butyric and those of higher molecular weight.

Acetic Acid forms by far the greater proportion of the volatile acids produced in the fermenting houses. It is formed in the souring of cane juice and skimmings, and is produced very quickly when a weak alcoholic liquor is exposed to the air. The oxidation of alcohol to acetic acid is brought about by a class of bacteria which are very abundant everywhere. The manufactures of flavoured rum makes acetic acid by fermenting rum cane juice and then pumping this liquor on to cane trash. So far this method is correct but I do not think the generality of distillers fully appreciate the importance of the free access of air in this part of this process. The acetic ferment requires oxygen,

Acetic acid is produced by other classes of bacteria and there is generally enough of it in still-houses.

Butyric and higher acids. Volatile fatty acids are produced when organic substances putrefy. Butyric and the higher acids are thus produced by the action of a considerable number of different bacteria especially a group to which the name of *proteus* has been given.

I have found organisms of this class in most of the distillery materials which I have examined and especially from the 'muck hole' of estates making flavoured rum. There is little doubt that these microbes contribute their quota of organic acids, but the chief agents in producing the desired flavour are B. Butyricus, B. Amylobactor and other allied forms.

The method, envolved by experience, of preparing what is called 'flavour' on estates making German rum, is a crude attempt to foster these microbes. Members belonging to this group and their allies are among the most common organisms in nature. They are especially plentiful in the soil. They exist in two states—the vegetative and the spore. The vegetative is a long rod of variable length. The spore develops within the rod and ultimately escapes by bursting the cell wall. If conditions are favourable the spore germinates and becomes a rod. Under unfavourable conditions it remains dormant, but it is practically tolerant of adversity, and can survive for a long time although placed in surroundings where it cannot exert its physiological functions. Hence the reason why, although this class of organism is so prevalent in distillery washes and other materials, its products are not so plentiful. As typical of the class I have referred to I have isolated Bacillus Butyricus from distillery materials and made a careful study of the conditions under which it thrives and performs its physiological functions. Bacillus Butyricus is an anærobic organism, that is, it will not develop unless it is grown out of contact with oxygen. The composition of the medium in

which it is placed is of importance. In pure cane juice its action is extremely sluggish. In a solution of glucose (invert sugar) to which some albuminous matter has been added it thrives luxuriantly and in 48 hours after inoculation sets up a strong fermentation. I have found that a medium composed of cane juice and the watery extract of yeast cells is very suitable. This medium closely corresponds to dunder with a little cane juice or molasses added. The temperature at which it grows best is about 35 deg. C. but it thrives very well at the ordinary room temperatures (about 26 deg C.)

Under these conditions this organism produces butyric acid along with small quantities of other volatile fatty acids such as propionic and acetic. The amount of acid, however, is small, not more than from .3 to .4 per cent unless some substance such as calcium carbonate be added to neutralise the acid as it is produced,

Besides the particular organism described there are others resembling it in its growth and products, some of which develop in contact with air, while others like the Butyricus described, require that oxygen be rigidly excluded.

The point of importance to the distiller is that these organisms ferment sugars converting them into acids, and if the acids be distilled along with alcohol under suitable conditions Aromatic Ethers will be produced.

The exclusion of air presents a difficulty not easily surmounted in a practical operation on a large scale, but in materials such as one finds in rum distilleries where the number and varieties of organisms are legion and the predominating members are aerobic (i. e. requires the presence of air) the chances are that those which require oxygen will rapidly develop as long as there is oxygen available, and will thrive best at or near the surface of the medium in which they are, while those of the Anaerobic type will find suitable conditions towards the bottom. This I believe is what actually takes place in distilleries where flavoured rum is made. I have successfully grown mixed cultures of aerobic and anaerobic organisms in this way in the laboratory.

The high flavoured rum distiller has found by experience that he must supply albuminous matter before he obtains a flavour. This for the most part is got from the thick sediment which settles from the dunder and the sludge from the fermenting vats. This sludge is for the most part yeast cells which provides a nutritious medium for bacteria.

Besides the volatile acids described there is always a large proportion of non-volatile acids. Lactic acid is produced from carbohydrates by means of what is known as the lactic ferment. This organism is ubiquitous and distillery conditions being favourable its products are plentiful. Being non-volatile it remains in the dunder, and here it is useful in preventing the volatilisation of basic substances produced by the bacteria and which would be injurious to the rum.

It is unnecessary to say that the chief organisms co the manufacture of rum are yeasts. While in other bran spirit industry, yeasts are almost the only organisms p the wash, it is very different in the case of Jamaica ru being left with a fairly free-hand it is truly a fight for t of the fittest, and the bacteria generally win in the end. so is this the case in flavoured washes that I have not to isolate yeasts from dead liquors, the Yeasts having b swamped by bacteria. The Yeasts generally found belo are known as wild varieties, and are obtained from the cane. The species known as schizosaccharomycetes i in Jamaica. It is easily distinguished from other f microscopic appearance. It forms long rod shaped cells more a huge bacterium than a yeast. Its mode of rep distinct from other species. Instead of forming buds it two, forming two individuals which increase in size divide into two.

I have found the distribution of this yeast to throughout the Island, but it is particularly plentiful on estates. In distilleries making high flavoured rum it is only yeast present in the wash. On other Estates about equal numbers to the oval forms.

On one estate where the development of the yeasts a special study, when the distillery started at the comme crop, oval forms which abound on the cane rind, wer forms which could be detected After a few cisterns h up the rod forms took possession of the wash. From other observations I conclude that the schizosaccharo less susceptible than the saccharomycetes to acid, and very acid washes such as are used on the Northside estat media for their development.

Of other constituents of rum 'Higher alcohols' ar in small amounts by an organism which is extremely a washes—*Bacillus Mesentericus* or the potato bacillus cular Alcohol produced is Butyl Alcohol which I be the predominant higher alcohol in Jamaica rum. Bacill tericus grown in a wash fermented by yeast gives a plea flavour to the dead liquor.

Higher alcohols, furfurol and aldehydes although in such minute traces that they cannot have much influe flavour. They may, however contribute in a slight deg is indefinitely referred to as 'Body,'

There cannot be any doubt but much of the valu of Jamaica rum are due to its high compound Ether con these Ethers be in the proper proportions the greater the more valuable is the rum.

The experiment made on an estate when the price of the rum was raised from 3 6 to 7 6 per gallon by simply increasing the Ethers, together with the analysis of rums already given, afford conclusive proof of the statement.

It follows then that the characteristics of Jamaica rum are derived from saccharine liquors rich in albuminous matter fermented by yeasts and bacteria. Granting that the main difference between high flavoured rum and Common Clean rum is in Ether content the process of manufacture is accountable for this difference, in as much as the general bacterial action is greatly increased and special bacteria are developed which produce acids which on combining with the alcohol form aromatic Ethers.

The question of practical importance is, can the fermentation be scientifically controlled so as to produce flavoured rum? At the present stage of our investigations a conclusive answer cannot be given.

Organisms grown in cultures often give very different products from that produced when they are cultivated in a pure state. There may be, either an interaction taking place between their fermentation products, or there may be altogether new products formed. This function of mixed cultures must not be overlooked in any attempt to reproduce a particular flavour by means of pure cultures. It is, indeed, almost certain that particular flavoured rums as now made can only be approximately similated by pure cultures.

Hitherto the distiller has been very much in the dark as to what are the agents at work in the production of flavoured rums. A more accurate knowledge of what constitutes the flavour and how it is produced shall minimise the risks of failure which have always been a very serious drawback to the industry.

With flavoured rum, and to a less extent with 'common clear' rum the methods of manufacture are wasteful of material. This must necessarily be so in order to produce a superior article, and should form one of the strongest arguments why inferior rum made by a less expensive process should be debarred from being sold as Jamaica rum. High gravities with incomplete attenuation, and slow fermentation with consequent loss of spirit by evaporation are bound to be uneconomical, but although a certain amount of material must be sacrificed in order to obtain quality, generally speaking there is much more waste in distilleries in Jamaica than is necessary. A better control should be exercised and some sort of balance should be struck between the amount of sugar given to the distillery and the amount of rum produced.

The usual method of checking gallons of rum against tons of sugar is very misleading, and it is worthless as a check. It may happen and I fear too often does happen, that the recovery of sugar from the juice is bad. I have found planters who checked their

rum in this way jubilant at the yield they were obtaining from their distilleries, but oblivious of the fact that the molasses supplied from the boiling house contained over 70 per cent. of sugar,—ten per cent more than they should contain.

There is a popular belief in Jamaica that good rum cannot be made on estates with modern sugar machinery. I have not found any evidence to support this belief. I can well understand that it would be difficult to make a superior rum where the amount of materials was too large for the capacity of the distillery. A slow fermentation is essential in order that the bacterial ferments may have time to act. In a rapid fermentation, yeast swamp the bacteria and hence the fermentation products of the bacteria are wanting. Given, however, the same conditions in the distillery I cannot see that the boiling-house plant has anything to do with the quality of rum. Reboiling molasses will lessen the amount of sugar to be fermented and so decrease the quantity of rum, but it cannot affect its quality.

When it becomes fully recognised from what source Jamaica rum derives its characteristics (and I think that has been fairly well established) the planter will be in a much better position to decide on what lines he is to improve his process. He should be able to judge how far he can economise on his materials without sacrificing quality.

The hap-hazard rule-of-thumb process should give place to a standardised method. A system of complete scientific control involving pure culture methods is impracticable, but an empirical formula based on scientific principles, after the manner used by British distillers, should be applied to the manufacturer of rum, and would do much to ensure uniformity of quality with the minimum waste of materials.