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Workshop on Fermentation Alcohol for Use as Fuel
and Chemical Feedstock in Developing Countries

THE POTENTIAL OF SUGAR CANE DERIVED ALCOHOL AS A FUEL IN JAMAICA*

by

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Brazil's dramatic programme of expansion of Anhydrous Alcohol Production for motor vehicle fuel has stimulated many other countries, particularly those with no indigenous petroleum supply, to consider similar programmes. Jamaica is among such countries and this presentation will outline the local factors which determine the economic feasibility of alcohol production for addition to motor vehicle fuel in Jamaica. The Brazilian programme must be seen against the background of the country's economic situation with particular reference to the following factors:-

a) Lack of any developed source of indigenous petroleum.

b) The availability of vast areas of virgin land with climate and rainfall suitable for growing sugar cane.

c) Possession of a highly developed local engineering/construction industry, capable of erecting virtually all the productive capacity required.

d) Government's desire to develop and colonise its virgin territory as part of its land development policy.

In contrast, only (a) above applies to Jamaica, which has:

b) A shortage of flat arable land, being largely mountainuous.

c) A small local engineering/construction industry, with limited capacity to manufacture sugar factories and/or distilleries.

d) An already densely populated country, with over 2 million people on a mountainuous island of 4,000 sq.miles.

It can be seen than that most of the politico/economic justification for implementation of the Brazalian alcohol programme does not apply to Jamaica. In spite of this, as Jamaica imports all its gasolene, the Sugar Industry Research Institute in conjunction with the OAS (Organisation of American States) and Tegri-Tecnica Agro-Industrial Ltda, Sao Paulo, Brazil carried out a

feasibility study[1] on the production of anhydrous alcohol in Jamaica for addition to gasolene for internal combustion engines. The results of this study will be viewed against the background of alcohol/rum production in Jamaica, with the earning/saving of foreign exchange as the most important single consideration for the island's economy.

1. History of Anhydrous Alcohol Production in Jamaica

In 1952, a distillation plant for production of anhydrous alcohol was built at Caymanas Sugar Factory, outside Kingston, Jamaica. This was done by the Sugar Manufacturers Association, stimulated by very low molasses prices and a poor overseas rum market. The alcohol so produced could be marketed duty free at a price equal to the then duty paid gasolene price. Government's prior approval for use of the alcohol as motor vehicle fuel on a duty free basis was obtained. The plant, supplied by ATV of England, was completed, with a capacity of 300 gallons per hour of anhydrous alcohol (by benzene azeotropic distillation of 96° alcohol from neighbouring distilleries.) Unfortunately by the time production commenced, government had changed its position on the decision to allow the alcohol to be sold duty free. This about-face was probably a result of both oil company pressures and a realisation of the revenue loss from the duty on gasolene replaced by duty free alcohol. Several hundred thousand gallons of anhydrous alcohol already produced was permitted to be added to gasolene for use on sugar estates only (10% on gasolene). Government purchased the anhydrous alcohol plant at cost less 5% depreciation, and closed it down. Today over 25 years later it still stands much as it was left, apart from the theft of most small non-ferrous fittings. The design however, is now so outmoded (e.g., channel caps instead of bubble caps on the columns) that it is unlikely to have much more than scrap value. Alternatively, it could be kept as an Ozymandias - like monument to the shortsightedness of some politicians.

Present Distillery Capacity in Jamaica

Jamaica has a history of distilling sugar cane juice and molasses which goes back to the 17th century. The island has presently six distilleries. Five

of them have continuous stills and can produce both alcohol and rum although one (Innswood) has no pot stills. One distillery (Hampden) has only pot stills and produces rum alone.

The Government, through the National Sugar Company, owns one distillery (Long Pond, Trelawny) and has a 51% share in two others (Monymusk and Innswood). The production of these distilleries is as follows:- (2)

TABLE 1 SPIRIT PRODUCTION 1978 IN PROOF GALLONS (p.g.) and Litres

Distillery	As Alcohol		As Rum		Total	
	p.g.	Litres	p.g.	Litres	p.g.	Litres
Appleton	322,000	834,000	1,600,000	4,146,000	1,922,000	4,980,000
Hampden	-	-	304,000	788,000	304,000	788,000
Innswood	661,000	1,713,000	120,000	311,000	781,000	2,024,000
Long Pond	-	-	462,000	1,197,000	462,000	1,197,000
Monymusk	284,000	736,000	1,112,000	2,881,000	1,396,000	3,617,000
New Yarmouth	-	-	694,000	1,798,000	694,000	1,798,000
					5,559,000	14,404,000

TABLE 2 JAMAICA'S RUM AND ALCOHOL PRODUCTION 1972-78

Year	Rum Million		Alcohol Million		Meths. Million		Total Million	
	p.g.	Litres	p.g.	Litres	p.g.	Litres	p.g.	Litres
1972	4.79	12.41	0.76	1.97	0.08	0.21	5.63	14.59
1973	5.60	14.51	0.90	2.33	0.08	0.21	6.58	17.05
1974	5.74	14.87	1.21	3.14	0.07	0.18	7.01	18.09
1975	6.42	16.64	1.20	3.11	0.07	0.18	7.69	19.93
1976	4.42	11.45	1.04	2.70	0.07	0.18	5.53	14.33
1977	5.01	12.98	1.09	2.82	0.08	0.18	6.18	15.98
1978	5.37	13.91	1.21	3.14	0.06	0.18	6.64	17.23

N.B. A proof gallon is one imperial gallon containing 57% v/v alcohol
One imperial gallon = 4,546 litres
The 'Litres' columns above refer to equivalent litres of alcohol

The capacities of most Jamaican distilleries are not fully utilised, due to the system of making rum and alcohol only to order. Under this system, distilleries cease production when orders on hand have been supplied. This results in erratic production figures, viz., 19.93 Million Litres in 1975, but only 14.33 in 1976. Such surplus distillery capacity could be utilised to make alcohol for conversion to anhydrous alcohol.

With the exception of two distilleries which use a very small amount of cane juice, all rum and alcohol is produced from molasses. Jamaica produces varying amounts of molasses in excess of distillery requirements, which excess is sold to the Caribbean Molasses Company at a price based on the New Orleans Price.

TABLE 3 MOLASSES PRODUCTION AND DISPOSAL 1972-78[3]

YEAR	Long Tons Total Production	DISPOSAL (LT)					
		Distilleries	%	Other Local	%	Export	%
1972	143,000	73,000	52	8,000	6	59,000	42
1973	129,000	81,000	64	7,000	5	39,000	31
1974	121,000	79,000	63	6,000	5	39,000	32
1975	120,000	86,000	78	3,000	3	21,000	19
1976	122,000	66,000	54	-	-	57,000	46
1977	117,000	75,000	64	10,000	9	36,000	29
1978	133,000	72,000	54	Not available		Not available	

Economics of Jamaican Molasses Usage

We shall consider the economics of three alternative uses for Jamaican Molasses namely:-

a) Direct export

b) Raw Material for Fuel Alcohol Production

c) Raw Material for Rum Production

Another use is manufacture of locally made animal feeds, this accounts for most of the "Other Local" uses in Table 3.

a) Direct Export of Molasses

Jamaica has the advantage of close proximity to New Orleans, therefore shipping costs (approx. US$10. per ton) do not significantly diminish the returns, which are based upon the landed New Orleans price. The export price for molasses fluctuates largely in relation to the corn price, as export molasses main use is as a substitute for corn in animal feeds.

TABLE 4 AVERAGE NET EXPORT PRICES IN US$/LONG TON FOR JAMAICAN MOLASSES 1973-78 (3)

1973	$ 22.	1977	$ 36.
1974	$ 43.	1978	$ 34.
1975	$ 47.	1979 (Feb.)	$ 65.
1976	$ 51.		

Taking for example the February 1979 price of US$75. per ton, less US$10./ton shipping costs gives a net revenue per ton of molasses of US$65. per ton. The average net export value of Jamaican molasses for five years 1975-79 is US$46.60 per ton.

b) Molasses as Raw Material for Fuel Alcohol Production

Assuming that one long ton of molasses (88° Brix, 0.565 LT total sugars) produces 67.7 imperial gallons of anhydrous alcohol (a yield in excess of the Jamaican average for 96% alcohol). Then the molasses cost alone is US$ 0.7, giving a projected total cost of production in Jamaica of US$1.05 per imperial gallon of anhydrous alcohol. Assuming one gallon of alcohol replaces one gallon of premium gasolene (Ex-refinery price Jamaica = US$0.62) then one ton of molasses will have a gasolene import

substitution value of 67.7 x 0.62 = US$42

c' Raw Molasses as Material for Export Rum Production

Jamaica has an international reputation for rum, especially the heavier flavoured types, which are virtually specific to Jamaica. On account of these specialised products and the island's historical association with rum, high prices are obtained for Jamaican Rum on the international market. Price is roughly proportional to the content of impurities - variously called congeners, esters or ethers. Export prices vary from over US$4.0 for "Continental Flavoured" at 1600 p.p.10^5ester content at the top end, down to approx US$1.75 (price per imperial proof gallon) for light (40 p.p.10^5esters continuous still rum. It should be noted that the cost of production, and in particular the quantity of molasses required to produce a proof gallon of rum is almost directly proportional to the amount of esters present in the rum. This is shown in Table 5.(4)

TABLE 5 GALLONS OF MOLASSES AT 88° BRIX PER GALLON OF PROOF RUM

Ester Content p.p. 10^5	Percentage of Total Sugars in Molasses				
	56	58	60	62	64
40	1.20	1.23	1.19	1.15	1.12
60	1.43	1.38	1.33	1.29	1.25
80	1.58	1.53	1.48	1.43	1.38
100	1.76	1.69	1.64	1.59	1.54
120	1.93	1.85	1.79	1.73	1.69
140	2.09	2.01	1.95	1.88	1.83
160	2.24	2.15	2.09	2.02	1.96
180	2.37	2.29	2.21	2.14	2.08
200	2.54	2.45	2.37	2.29	2.22
220	2.66	2.56	2.47	2.39	2.32
240	2.78	2.68	2.59	2.50	2.43
260	2.86	2.76	2.67	2.58	2.51
280	3.01	2.90	2.80	2.71	2.63
300	3.11	2.99	2.90	2.86	2.72

Taking a very conservative average export price of US$2.0 per proof gallon, and the Jamaican yield of 89 proof gallons spirit per long ton molasses, then each ton of molasses earns Jamaica US$2 x 89=US$178.

CONCLUSIONS

On the basis of foreign exchange earnings/savings, under the present gasolene/molasses price ratio, the use of Jamaican molasses for production of fuel alcohol compares very favourably with its conversion to Jamaican Rum for export, or even direct molasses export. The magnitude of the differences indicate that conversion of all Jamaican molasses to rum, coupled with an aggressive sales promotion for Jamaican Rum would be the optimum use for the island's molasses. This agrees with an earlier study[5] done in 1974 which projected a cost of US$0.98/1G, based on a molasses price of US$55/LT. Accepting that under present conditions, use of Jamaican molasses for Fuel Alcohol production is uneconomic, let us examine the possibility of producing fuel alcohol directly from sugar cane juice.

Anhydrous Alcohol from Sugar Cane (Direct Alcohol)

Two possibilities exist, namely:-

a) From cane produced surplus to sugar production requirements, e.g., by increasing the yield from existing cane lands.

b) From cane produced by developing new land

In Jamaica, given land and development costs (b) is uneconomic. We shall therefore examine only (a).

a) The establishment of a plant to grind 256,000 tons of cane in 167 days with fermentation and distillation capacity to produce 4 Million 1.G. anhydrous alcohol/year was estimated to cost US$9.1M of which US$7M was foreign exchange. Calculations based upon an alcohol/cane ratio of 15.65 imperial gallons anhydrous alcohol per long ton cane and a cane cost of US$16./ton (See Table 6) give a projected cost of US$1.45

TABLE 6 COST OF FACTORY/DISTILLERY FOR PRODUCTION OF ANHYDROUS ALCOHOL FROM SUGAR CANE

T.I.G.R.I. JAMAICA	DISTILLERY USING SUGAR CANE 24,00 IG/DAY-4,008,000 IG/YEAR					TABLE 6	
Specifications	Unit	Quantity per 1G of Alcohol	Quantity Total	Value Cost/Unit	Value Total Cost	Cost per 1 1G	
				J$	1,000J$	J$/1G	US$/ 1G
TOTAL COST					7.425	1.8076	1.4461
VARIABLE COSTS					5,684	1.4181	1.1345
SUGAR CANE	LT	0.06392	256,192	20.00	5,123	1.2782	1.0225
CHEMICALS					85	0.0212	0.0170
Superphosphate	lb	0.0286	114,629	0.1012	12		
Sodium Aluminate	lb	0.0029	11,623	0.3343	4		
Alluminium Sulphate	lb	0.0098	39,278	0.1640	6		
Sulphuric Acid	lb	0.1103	442,082	0.0069	30		
Benzol	lb	0.0088	35,270	0.3047	11		
Sodium Carbonate	lb	0.0049	19,639	0.3047	6		
Anti-Foam	lb	0.0056	22,445	0.7315	16		
LABORATORY MATERIALS					24	0.0060	0.0048
LUBRICANTS AND GREASE	lb	0.0112	44,890	0.300	13	0.0032	0.0026
PRODUCTION PERSONNEL					439	0.1095	0.0876
Supervisors	n		6	10.200	61		
Labourers	n		75	5.040	378		
FIXED COSTS				(Invest)	1,561	0.3895	0.3116
				1,000J$	841	0.2008	0.1676
DEPRECIATIONS							
Buildings	%		3.5	1,875	66		
Equipment and Erection	%		8.33	8,775	731		
Vehicles	%		20.00	17	3		
Pre-Operational Expenditure	%		10.00	413	41		

TABLE 6 Cont'd

T.I.G.R.I. JAMAICA	DISTILLERY USING SUGAR CANE 24,000 1G/DAY-4,008,000 1G/YEAR					TABLE 6	
Specifications	Unit	Quantity		Value		Cost per 1 1G	
		Per 1G of Alcohol	Total	Cost/Unit	Total Cost		
				J$	1.000J$	J$/1G	US$/1G
MAINTENANCE					330	0.0823	0.0659
Buildings	%		0.5	1,875	9		
Equipment	%		4.0	8,000	320		
Vehicles	%		4.0	17	1		
INSURANCE					98	0.0246	0.0197
Buildings	%		0.5	1,875	9		
Equipment and Erection	%		1.0	8.775	88		
Vehicle	%		4.0	17	1		
STAFF PERSONNEL				Cost Unit	124	0.0309	0.0247
Factory Manager	n		1	18,000	18		
Technical Assistants	n		5	12,000	36		
Engineers	n		2	10,000	20		
Labourers and Clerks	n		10	5,040	50		
ADMINISTRATION PERSONNEL					128	0.0319	0.0255
Financial Manager	n		1	18,000	18		
Assistants	n		5	12,000	60		
Clerks	n		10	5,040	50		
MISCELLANEOUS					40	0.0100	0.0080

per imperial gallon of anhydrous alcohol. This alcohol would replace 4% of Jamaica's projected gasolene consumption. To avoid Government subsidy the higher cost of 4% alcohol would necessitate an increase in price of gasolene to the consumer of approx. 4% of the 1978 price.

The high initial capital cost could be lowered by:-

a) Utilising existing sugar factory capacities to extract cane juice, which could be evaporated to thick syrup at 72° Brix for transportation to a distillery, for storage and conversion to 96% v/v alcohol, using present excess distillery capacity .

b) Transfer to a central distillery for conversion to anhydrous alcohol azeotropic distillation with either benzene or cyclohexane.

The most likely sites for the central distillery are Monymusk or Bernard Lodge. Monymusk has a realistic capacity for year-round operation of over 2M proof gallons (5.18M Litres alcohol). It is also close to New Yarmouth and Innswood distilleries, each of which is capable of increased output, given year-round operation. Bernard Lodge has no distillery but is strategically located near a major road junction close to Kingston. To quantify the potential increased output is difficult, but an estimate can be given, on the assumption that:-

a) 12 month distillery operation is practiced

b) Existing fermentation/distillation technology is improved

If so, then the author estimates that an overall 20% increase in output is possible over even the 'peak' year of 1975. This would give Jamaica an output of 9.2M p.g. (23.9M Litres alcohol equivalent). This would give extra alcohol capacity of 2.6M p.g. (6.7M Litres) over the 1978 production. Use of this extra capacity for production of 96% alcohol for conversion to anhydrous alcohol, assumes however, that there would be no increase in rum

production from the existing distilleries. The restricting factor in expansion of rum production could of course, be the establishment of a ceiling on rum sales. Opportunities for expansion of the E.E.C. market for Jamaican are investigated in ref. 5.

When should Jamaica invest in an anhydrous alcohol project?

It has been previously observed that the price of gasolene is likely to rise relative to most other prices. If this occurs over a sufficiently long period, there will come a time in which the investment in anhydrous alcohol production for gasolene substitution will become an economically viable project.

NUMBER OF YEARS WHICH WILL PASS (AFTER 1977) PRIOR TO OBTAINING A FIRST YEAR RETURN AT LEAST EQUAL TO 11% ON THE CAPITAL INVESTED IN AN ANHYDROUS ALCOHOL PROJECT

	Assumed rate of annual premium gasolene gal price increase		
Project Option	5.5%	9%	15%
Direct alcohol	19	11	6
Alcohol from Molasses	12	7	3
Alcohol from Cane and Molasses	14	8	4

SUMMARY

Jamaica's agro/economic situation differs greatly from that of Brazil, resulting in most of the factors which favour production of fuel alcohol directly or indirectly from sugar cane being non-applicable to Jamaica. Use of Jamaican molasses for production of fuel alcohol cannot be justified economically, as a much higher return in foreign exchange is obtained by converting the

molasses to Jamaican Rum for export, or even by direct export of molasses. Production of fuel alcohol from sugar cane juice by the establishment of a new cane milling/fermentation distillation facility is economically unjustifiable but possibilities exist for reducing the high capital investment involved by use of surplus existing sugar factory/distillery capacities. Projectors of the rate of increase of gasolene prices necessary to make the production of fuel alcohol in Jamaica economically viable are made.

A summary of present rum and 96% v/v alcohol production in Jamaica is given, with the output of individual distilleries, and data on yields of rum types compared with alcohol is presented.

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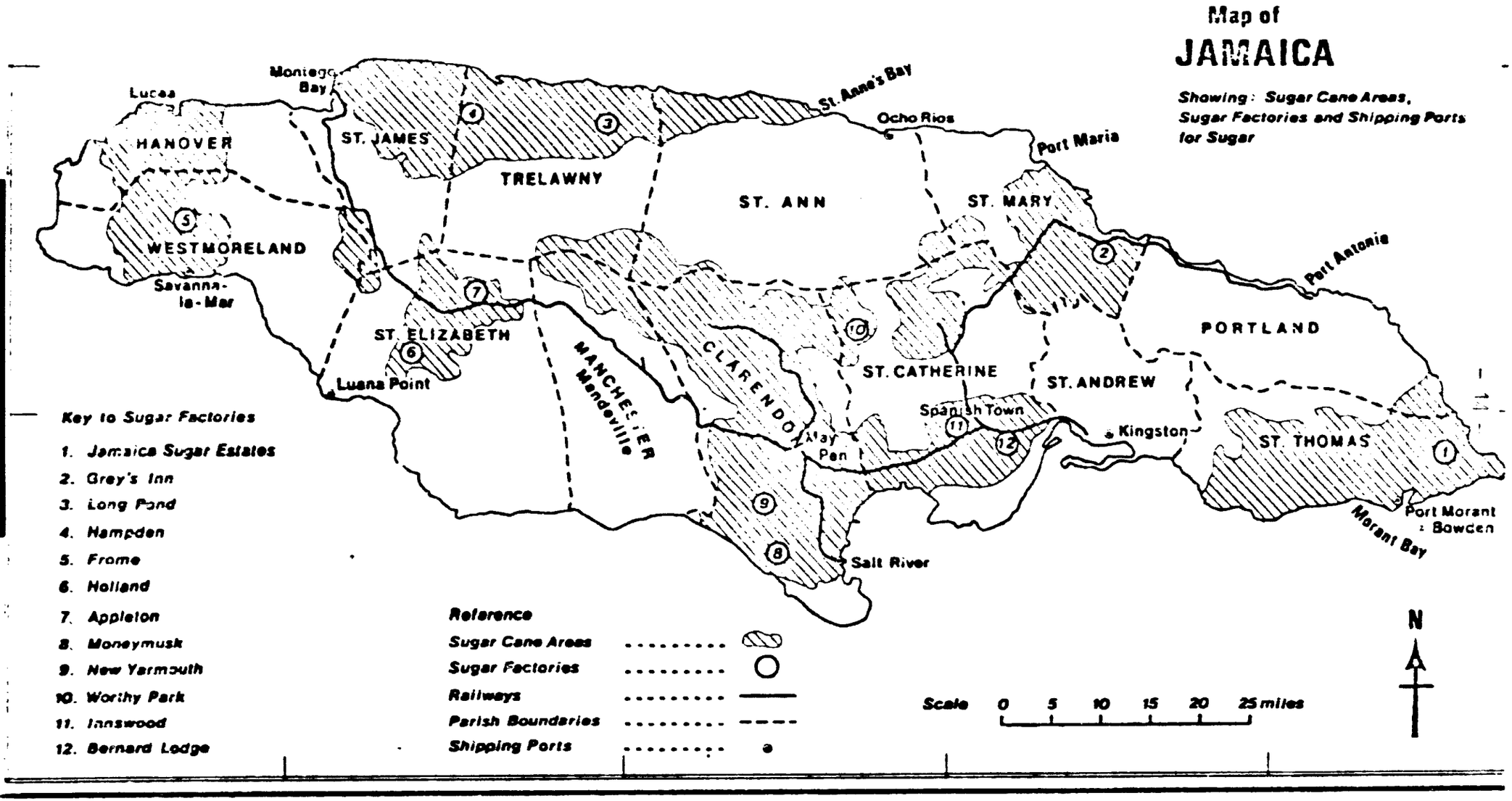
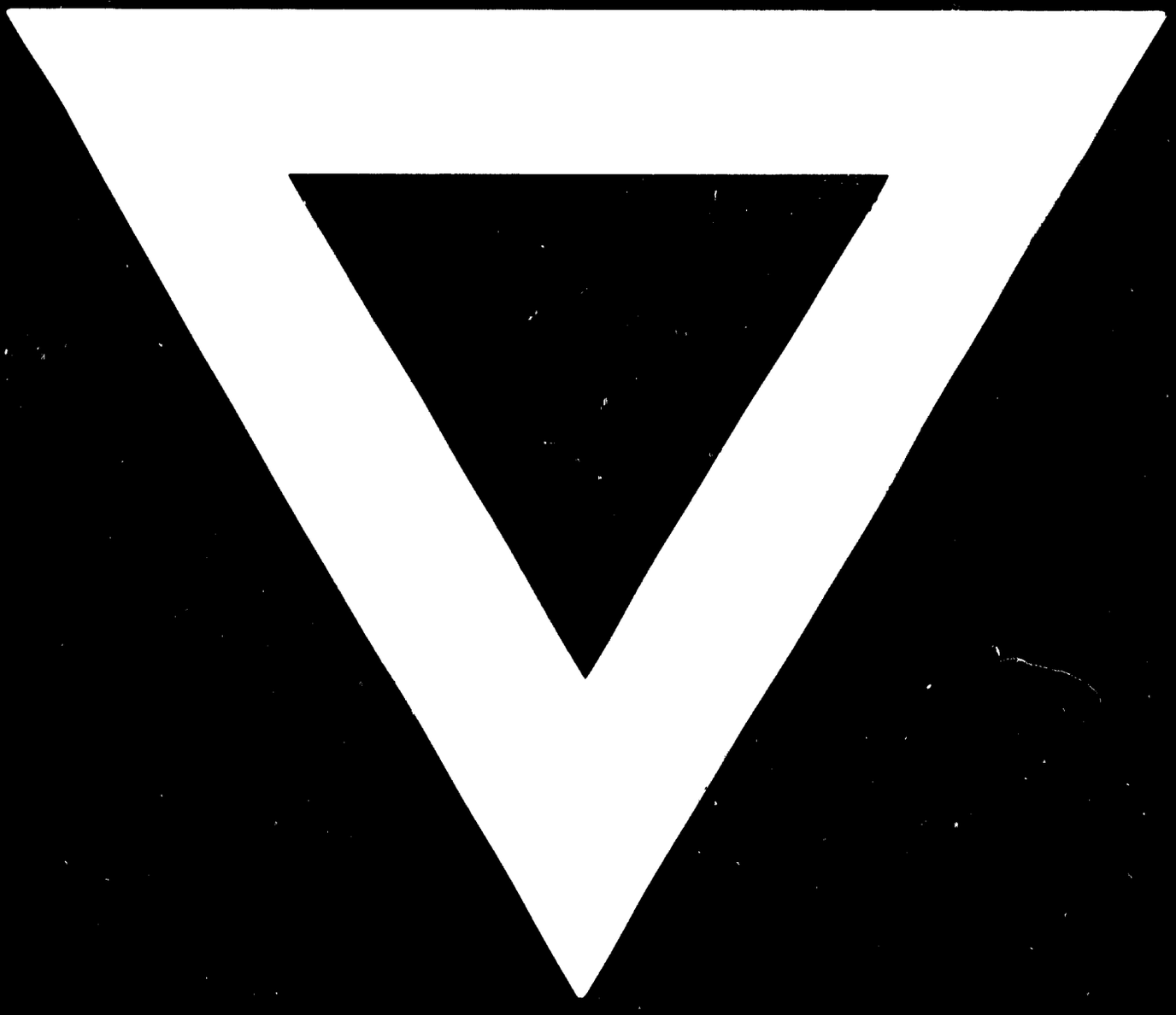

Map of
JAMAICA
Showing: Sugar Cane Areas, Sugar Factories and Shipping Ports for Sugar
Montego Bay
Lucea
HANOVER
ST. JAMES
TRELAWNY
St. Anne's Bay
Ocho Rios
Port Maria
ST. ANN
ST. MARY
WESTMORELAND
Savanna-la-Mar
ST. ELIZABETH
Luana Point
MANCHESTER
Mandeville
CLARENDON
Alley
Pen
ST. CATHERINE
Spanish Town
Kingston
ST. ANDREW
PORTLAND
Port Antonio
ST. THOMAS
Port Morant
Bowden
Morant Bay
Salt River
Key to Sugar Factories
1. Jamaica Sugar Estates
2. Grey's Inn
3. Long Pond
4. Hampden
5. Frome
6. Holland
7. Appleton
8. Moneymusk
9. New Yarmouth
10. Worthy Park
11. Innswood
12. Bernard Lodge
Reference
Sugar Cane Areas
Sugar Factories
Railways
Parish Boundaries
Shipping Ports
Scale 0 5 10 15 20 25 miles
N

G - 89



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