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POTENTIAL AVAILABILITY OF FERMENTATION ALCOHOL FROM SUGARS AND STARCHES IN DEVELOPING COUNTRIES*

by

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INTRODUCTION

The increasing price of petroleum products since 1973 has focussed considerable attention on the use of alternative sources of energy. Of particular importance in recent years has been the development of processes for the large-scale production of ethanol by fermentation from carbohydrate raw materials. This ethanol could replace a proportion of gasolene in motor engines, and is often described as power alcohol.

In theory, all starch-containing crops, such as wheat, barley, maize, rice, potatoes, as well as sugar, can be fermented to alcohol. However, only sugars and starchy roots, which have a high carbohydrate content, can be considered economically feasible raw materials. These crops are grown in Europe and N. America, as well as in many developing countries.

In this paper, the present and projected availability of sugar (including raw sugar and molasses) and starchy roots in developing countries is evaluated, in order to assess the amounts of fermentation alcohol that could be produced in those countries by 1985. These crops could represent renewable sources for the production of alternative sources of energy.

AVAILABILITY OF SUGAR

Sugar is grown in Europe, N. America and in many developing countries. However, its price of production in Europe and N. America is much higher than elsewhere. Recently published data by the USDA for 1977 (see Table 1) illustrates this point.

From this table, it can be seen that the average cost of producing raw sugar in the developing world is about US 8½ c/lb. Argentina, Philippines, El Salvador and Honduras have costs at about this level. Other countries of the Caribbean and Central America are more expensive, from 9½-13½ c/lb. Brazil is considerably lower at 5-8 c/lb.

By contrast, in Europe, the cheapest producer, France, has costs of about 14½ c/lb, and W. Germany, at 21 c/lb. Although major producers like Australia (12 c/lb) and S. Africa (15 c/lb) have lower costs, by the time freight charges are added, the cost of the sugar, landed in Europe, would be similar to European levels.

Table 1

Sugar Production Costs 1977

	US c/lb
Developing countries, generally Philippines, Argentina	8.5
Central America	9.5-13.5*
of which:	
- Belize	13.2
- Costa Rica	9.5
- El Salvador	8.9
- Guatemala	9.6
- Honduras	8.8
- Nicaragua	13.7
- Panama	13.5
Dominican Republic	10.0
Caribbean	10.5-13.5**
India	11.4
Mexico	8.0-10.0
Taiwan	9.5
Australia	12.0
S. Africa	9.5
EEC:	
- France [lowest]	14.3
- W. Germany [highest]	21.0

* Due to smallness of holdings
** Due to low productivity

In Table 2, world sugar production since 1960 is given and projections are made to 1985. It can be seen that the share of sugar in developing countries has increased slowly from 45-46% of the world's total in the early 1960's, and is expected to reach 52% by 1985.

In Europe and N. America, consumption of sugar per caput has reached a plateau, and in several countries, is even beginning to fall, so that an increase in production in those countries from 41m ton in 1975 to 48m ton in 1985 - about 1½%/year - will be sufficient to cater for any extra needs required for population growth.

As far as sugar is concerned, therefore, we shall consider those quantities which are surplus to requirements in the producing country as potential raw material for alcohol fermentation by 1985.

Twelve groups of developing countries, including Argentina, Brazil, Central America and Caribbean, Cuba, Mexico, Philippines, India, Taiwan, Thailand, Dominica, Sudan, Ivory Coast, produce over 75% of the world's sugar, as shown below:

Table 2

World Sugar Production 1960-1985 (m ton)

	Total production	Of which developing countries
1961/5 (average)	57	26
1970	74	37
1975	81	40
1980	94	49
1985	100	52

	1975	1985
Total production of sugar in developing countries	40m ton	52m ton
Of which production of 12 major countries	30.5m ton	39.6m ton
% of total	76.3	76.2

Projected production and consumption for these 12 countries, as well as actual figures for 1975, are given in Table 3. By subtracting consumption from production, an estimate is made of the amount produced which is surplus (occasionally deficient) to local requirements. This surplus was about 14.4m ton in 1975, and is expected to be 18.7m ton in 1985 - an increase of about 4.3m ton.

As mentioned previously, imports into Europe and N. America are unlikely to increase, but may even diminish. Thus, at least 4.3m ton of sugar in these twelve countries, could therefore be converted to alcohol by 1985.

Table 3

Sugar Balance Sheets of Major Producers in the Developing World

1975-1985 [000 ton]

		-- 1975 --		-- 1980 -		-- 1985 ---	
Argentina	Production	1,650		1,800		1,900	
	Consumption	1,020		1,100		1,200	
	Surplus		430		700		700
Brazil	Production	8,000		9,500		10,500	
	Consumption	4,200		5,000		5,700	
	Surplus		3,800		4,500		4,800
Central America & Caribbean	Production	1,200		2,300		2,400	
	Consumption	500		700		800	
	Surplus		700		1,600		1,600
Cuba	Production	6,000		7,000		7,200	
	Consumption	750		850		950	
	Surplus		5,250		6,150		6,250
Mexico	Production	2,800		2,900		2,900	
	Consumption	2,300		2,700		3,100	
	Surplus		500		200		- 200

contd/..

Table 3 (contd)

		-- 1975 --		-- 1980 -		-- 1985 --	
Philippines	Production	2,640		2,600		2,600	
	Consumption	890		900		1,050	
	Surplus		1,750		1,700		1,550
India	Production	4,950		5,300		5,850	
	Consumption	4,800		5,200		5,950	
	Surplus		150		100		- 100
Taiwan	Production	890		1,050		1,050	
	Consumption	390		400		500	
	Surplus		500		650		550
Thailand	Production	950		1,900		2,300	
	Consumption	500		900		1,000	
	Surplus		450		1,000		1,300
Dominica	Production	1,300		1,300		1,400	
	Consumption	00		00		200	
	Surplus		1,100		1,100		1,200
Sudan	Production	140		320		1,000	
	Consumption	300		320		350	
	Surplus		- 160		-		650
Ivory Coast	Production	0		200		500	
	Consumption	90		100		110	
	Surplus		- 90		100		390

In Table 4, it is shown that if all the 18.7m ton sugar produced in these countries by 1985 were fermented, this would come to 8.45m ton alcohol. Only 23% of this, ie 4.3m ton, represents the amount of sugar that could actually be converted, which could yield about 2m ton alcohol.

Table 4

Alcohol obtained from all Sugar grown in

12 Major Developing Countries 1985

	000 ton
Argentina	310
Brazil	2,140
Central America & Caribbean	710
Cuba	2,790
Philippines	690
Taiwan	240
Thailand	580
Dominica	530
Sudan	290
Ivory Coast	170
Total:	8,450

Based on a yield of 1 ton alcohol from 2.25 ton sugar

AVAILABILITY OF MOLASSES

The same twelve developing countries that dominate sugar production also produce most of the molasses. The total world production of molasses was estimated to be 27m ton in 1975, and this is projected to reach 33m ton in 1985. The twelve major developing countries produced 9.7m ton in 1975, and are projected to produce 12.8m ton by 1985, ie 75% and 80% of the developing countries' total.

The availability and use of molasses in these twelve countries in 1975 is shown in Table 5. The figures of production and export are from data supplied from the US Department of Agriculture, those of internal use are obtained by subtraction.

Thus in 1975, some 3.3m ton, about one-third of total production of molasses, was exported, and two-thirds used locally (6.4m ton). It must be assumed that the molasses which are exported have to bear the costs of transportation, and the price obtained for them in the exporting country therefore is relatively low.

Table 5

Production and Use of Molasses in 12 Major Developing Countries 1975 [000 ton]

	Production	Export	Internal use
Argentina	560	...	560
Brazil	1,760	1,000	760
Central America & Caribbean	360	160	200
Cuba	1,360	400	960
Mexico	1,250	500	750
Philippines	1,050	660	390
India	1,800	-	1,800
Taiwan	230	-	230
Thailand	880	500	380
Dominica	370	50	320
Sudan	40	-	40
Ivory Coast	-	-	-
Total:	9,660	3,270	6,390

Many countries have considered converting their own molasses to ethanol, as in Brazil, where all export of molasses has ceased since 1977 due to its demand as a fermentation raw material for the very ambitious Brazilian power ethanol project.

We have assumed that all molasses exported from these countries in 1975 could be considered as potentially available for domestic use by 1985 if a project such as that in Brazil were initiated. In Table 6, the total availability of molasses for ethanol by 1985 has been assessed.

It can be seen from Table 6 that Thailand will have the largest potential quantity of molasses available as a fermentation material in 1985. Next comes Brazil (at present the largest producer), and then Cuba and the Philippines.

In Table 7, the amount of alcohol that could be obtained from molasses is estimated at 1.9m ton, which is almost the same as the amount that can be obtained from sugar (2m ton).

Table 6

Availability of Molasses in 1985 from 12 Major Developing Countries [000 ton]

	Production			Exported	Potentially available
	1985	1975	Increase 1975-1985	1975 [from Table 5]	
	(a)	(b)	(c)*	(d)	(e)**
Argentina	640	560	80	-	80
Brazil	2,100	1,760	350	1,000	1,340
Central America & Caribbean	720	360	360	160	520
Cuba	1,590	1,360	230	400	630
Mexico	1,300	1,250	50	500	550
Philippines	1,000	1,050	- 50	660	610
India	2,140	1,800	340	-	340
Taiwan	320	230	90	-	90

contd

Table 6 (contd)

	Production			Exported	Potentially available
	1985 (a)	1975 (b)	Increase 1975-1985 (c)*	1975 [from Table 5] (d)	(e)**
Thailand	2,170	880	1,290	500	1,790
Dominica	400	370	30	50	80
Sudan	300	40	260	-	260
Ivory Coast	150	-	150	-	150
Total:	12,830	9,660	3,170	3,270	6,440

* (c) = (a) - (b)
** (e) = (c) + (d)

Table 7

Potential Yield of Alcohol from Surplus Molasses

in 12 Major Developing Countries 1985

	000 ton
Argentina	25
Brazil	400
Central America & Caribbean	160
Cuba	190
Mexico	165
Philippines	185
India	100
Taiwan	25
Thailand	535
Dominica	25
Sudan	75
Ivory Coast	45
Total:	1,930

Based on a yield of 1 ton alcohol from 3.3 ton molasses

AVAILABILITY OF STARCHY ROOTS

Starchy roots of tropical origin include cassava (tapioca, manioc, mandioca), taro, yams, cocoyams, sweet potatoes and many similar crops which are grown in many countries of the world. In Table 8, total production of these crops in 1975 is given and projected to 1985.

The roots are valued mainly for their starch content, and usually form the major component of the diet of the countries where they are grown. Quantities exported are small, and the largest proportion of these exports are from Thailand into the EEC, where the cassava is used in animal feed.

As is seen from Table 8, the major producers of starchy roots are Brazil, Nigeria and Indonesia. India is not far behind, and should soon overtake Indonesia. Thailand is increasing its output rapidly, and is the only exporter of significance. By 1985, Thailand should share fifth place with Zaire.

It can be expected that by 1985, food uses of starchy roots will not increase above present levels. Any increase in production of these crops by 1985, therefore, will be available for industrial use, such as ethanol fermentation.

Ten countries represent nearly 95% of total production of starchy roots. It is interesting to note that five of these countries are also major sugar producers.

Table 9 shows the yield of alcohol that can be obtained from 28m ton of additional output of starchy roots projected by 1985 in these ten countries. The 2m ton of cassava grown elsewhere can be ignored.

Table 8

Production of Starchy Roots, including Cassava, Yams, etc.

1975 projected to 1985 (000 ton)

	1975	1985	Increase 1975-1985
World:			
Cassava	102,000	128,000	26,000
Taro	4,000	5,000	1,000
Yams	22,000	25,000	3,000
Others	2,000	2,000	0
Total:	130,000	160,000	30,000
By country:			
Ghana	3,600	4,000	400
Ivory Coast	3,100	4,000	900
Nigeria	27,500	30,000	2,500
Tanzania	6,500	8,000	1,500
Zaire	9,500	12,000	2,500
Brazil	29,200	36,000	6,800
Colombia	3,400	5,000	1,600
India	14,200	20,000	5,800
Indonesia	16,300	17,000	700
Thailand	6,700	12,000	5,300
Others	10,000	12,000	2,000
Total:	130,000	160,000	30,000

Table 9

Potential Yield of Alcohol from Excess Production of Starchy Roots 1975-1985

	000 ton
Ghana	40
Ivory Coast	90
Nigeria	250
Tanzania	150
Zaire	250
Brazil	680
Colombia	160
India	580
Indonesia	70
Thailand	530
Total:	2,800

Based on a yield of 1 ton of alcohol from 10 ton cassava

SUMMARY

The most important carbohydrate crops for potential conversion to ethanol are sugar and starchy roots (cassava, etc.).

In Europe and N. America, these crops are expensive and protected by government subsidies, hence they can not serve as cheap raw materials for ethanol fermentation.

In developing countries, however, these crops are usually cheap, and any production in excess to local demand is exported to other countries at relatively low prevailing world prices.

We consider therefore that in developing countries, excess production of sugar, molasses and starchy roots could be converted to industrial ethanol more profitably than export of the basic raw materials at commodity prices.

The following regions and countries represent the most important producers of these crops: Central America and Caribbean, Argentina, Brazil, Colombia, Cuba, Dominica, Mexico, India, Indonesia, Philippines, Taiwan, Thailand, Ghana, Ivory Coast, Nigeria, Sudan, Tanzania and Zaire.

We have estimated that by 1985, if all the excess production of these crops were converted to ethanol, it would yield :

6.7m ton of ethanol

- of which 2.0m ton from sugar
  1.9m ton from molasses
  2.8m ton from starchy roots

This is shown in detail in Table 10.

Two countries, Brazil and Thailand, which have significant resources of these raw materials, account for just over 40% of the total ethanol potential. Cuba and India account for a further 20%. The Philippines, Nigeria and Zaire follow. Allowing for the practical difficulties of collection, it is unlikely that any of the other countries could support more than one major ethanol plant.

Table 10

Summary: Potential Availability of Alcohol from Sugar, Molasses and Starchy Roots 1985 [000 ton]

	From sugar*	From molasses	From starchy roots	Total
Central America & Caribbean	170	160	-	330
Argentina	75	25	-	100
Brazil	505	400	680	1,585
Colombia	-	-	160	160
Cuba	660	190	-	850
Dominican Republic	125	25	-	150
Mexico	-	165	-	165
Total America	1,535	965	840	3,340
India	-	100	580	680
Indonesia	-	-	70	70
Philippines	165	185	-	350
Taiwan	55	25	-	80
Thailand	135	535	530	1,200
Total Asia	355	845	1,180	2,380

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Table 10 (contd)

	From sugar*	From molasses	From starchy roots	Total
Ghana	-	-	40	40
Ivory Coast	40	45	90	175
Nigeria	-	-	250	250
Sudan	70	75	-	145
Tanzania	-	-	150	150
Zaire	-	-	250	250
Total Africa	110	120	780	1,010
World total:	2,000	1,930	2,800	6,730

* Availability for the individual countries shown in Table 4, has been reduced proportionately to give a total of 2m ton (see text)

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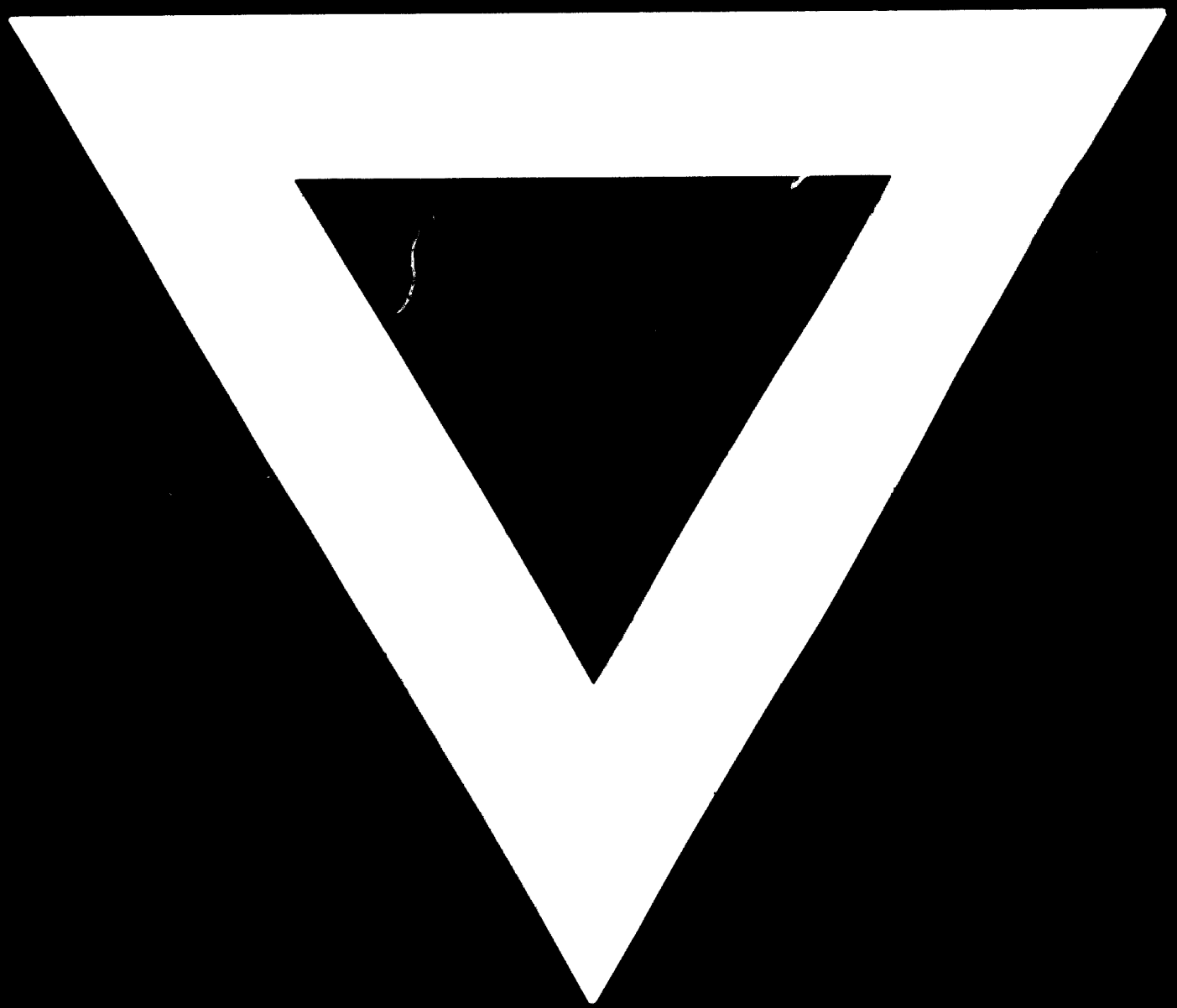

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