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Workshop on Fermentation Alcohol for Use as
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Vienna, Austria, 26 - 30 March 1979

TRENDS IN THE PRODUCTION OF ETHYL ALCOHOL BY FERMENTATION*

by

R.C.B. Carracedo**

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** Head of Department, Cuban Research Institute of Sugar Byproducts, Cuba

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ABSTRACT

TRENDS IN THE PRODUCTION OF ETHYL ALCOHOL BY FERMENTATION*

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R. G. B. Carracedo**

The energy crisis has brought about a substantial re-evaluation of the ways of obtaining fuels; hence a strong interest in carbohydrates as potential sources of raw materials has developed.

The paper presents an analysis of the development of world ethanol production. It offers a panoramic view of the trends in the period 1935-1970 in the United States, France, United Kingdom and Japan.

The paper also analyzes the new trends since 1973 in Brazil, Philippines, United States, Australia, England, Japan, Thailand, Costa Rica, Hawaii, Zambia, Paraguay.

An analysis of the Cuban alcohol industry and a world balance of ethyl alcohol production by fermentation is presented.

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** Head of Department, Cuban Research Institute of Sugar Byproducts, Cuba

PREFACE -

In the period between 1945 and the beginning of the 70's a fast displacement in the preference of the producing countries takes place in favor of the obtention of ethyl alcohol from the petroleum by sinthesis. The fermentation method was limited to the production of alcohol for beverages.

The increases in the oil price from 1973 forced a deep reconsideration that bring about a new change in the interest in this case toward the fermentation processes for the production of ethyl alcohol from carbohidrates as an alternative to solve the energy crisis. In the present paper an analysis of this phenomenom in the period 1935-1970 is presented as well as a profile of the development of the situation from 1973 in various countries (developed and developing ones). An information about the cuban alcohol industry is offered complemented with a world balance of the ethyl alcohol production by fermentation.

THE TENDENCY IN THE ETHANOL WORLD PRODUCTION UNTIL THE BEGINNING OF THE 70'S -

After the Second World War the synthetic alcohols begin to displace the ones obtained from fermentation in all the industrial uses. The United States are an example of this tendency as shown below.

UNITED STATES

Alcohol Production in the U.S.A.

	Type of Production %	
Year	Fermentative	Synthetic
1935	90	10
1954	30	70
1963	9	91

The same tendency toward the synthetic production of ethanol is observed in others highly developed producing countries.

Being displaced the alcohols from fermentation for the industrial uses and under the circunstances of a strongly controlled markets for human consumption the price of the ethanol from fermentation was forced to follow the decreasing tendency of the price of the synthetic one obviously obtained at a lower cost.

At the beginning of this period the blackstrap molasses, a byproduct of the sugar cane industry, supplied 80% of the raw material for the ethyl alcohol world production. With the decrease in the ethanol production from fermentation and the low price of the ethyl alcohol greater quantities of molasses were available for other uses, for instance as animal feedstuff.

FRANCE

The French industry, one of the greatest producers of ethyl alcohol carried out, until 1967, all its production by fermentation. In 1967 a plant of synthetic alcohol began to produce 800 000 hl per year.

In the period 1970-1971 France produced 831 000 hl of ethanol by synthesis, 1286 hl from beet molasses, 623 000 hl from cane molasses, 108 000 hl from fruits and 476 000 hl from wines and others, for a total production of 3 324 000 hl per year.

UNITED KINGDOM

Another great producer of alcohol with an important amount of it as whisky. In 1966-67 the U.K. produced 4 671 000 hl per year, 70% of this production from malt and grains.

JAPAN

At the beginning this country used to produce ethyl alcohol from fermentation using molasses imported from other countries. In 1965 the production of synthetic ethanol started in two factories with capacities of 600 000 and 250 000 hl per year. Afterward its 7 factories for the production of ethanol by fermentation were closed mainly due to pollution troubles. The new capacities for synthetic ethanol were devoted to cover the industrial demand of this product.

CHARACTERISTICS OF THE MARKET

In general, the characteristics of the ethanol world market until the beginning of the 70's were the followings:

- The ethanol demand as solvent and as an intermediate chemical was satisfied with the production carried out by the oil corporations.
- The main consuming countries produced enough to satisfy their own demands.
- The demand for alcohol from fermentation was limited (cosmetics, beverages, pharmaceuticals) and was satisfied the resources of each country.
- In the developing countries the objectives of this industry were the increase of local industries and the integral use of the internal resources.

THE TENDENCY OF THE WORLD PRODUCTION OF ETHANOL FROM 1973 ON -

As a consecuence of the increases of the oil price from 1973 the situation of the alcohol world production change drastically. The main characteristics of this change could be sumarized in this way:

- The fermentation method becomes the most attractive way for the synthesis of ethanol.
- New non-conventional, renewable raw materials are tested for the production of ethanol by fermentation.
- The sugar producing countries start studies to increase the production of ethanol using the byproducts of the sugar industry as raw materials.
- The sugar cane seems to be the most attractive carbon source for the fermentative synthesis of ethanol.

A summary of the tendencies in the alcohol industry of some countries which had announced important increases in the production is offered below:

BRAZIL

As a result of the oil crisis the brazilian alcohol plan stated an increase in the production in the range of 30-47 millions hl as in order to cover between 15 to 20% of the gasoline demand for 1980. According to the previous statement the plan would be implemented in the following ways:

- Increase in the production capacity of the existing distilleries annexed to the sugar factories.
- Installation of new alcohol distilleries annexed to sugar factories.
- Production of alcohol by fermentation from the sugar cane juice in new factories independent from the sugar mills.

The ethanol obtained will be used as a substitute of the gasoline and as a raw material for the synthesis of ethylene.

Since 1975 as a consecuence of the above mentioned plan this country has spread out its sources of ethanol. In 1978 its production plan was set at 1.5 billions liters and the plan for 1980 will be 4.7 billions liters.

At the beginning of 1978 it was reported that the investment in the alcohol program from the sugar cane had been of $178 million dollars. In different states of the country the gasoline-alcohol mixture is currently used. In Sao Paulo, for example, there are companies which

add up to 20% of alcohol to the automobile-gasoline.

The Salgema Industrias Químicas granted a contract for an ethylene plant of 120 000 tons per year to the Rhone Poulenc and Litwin with the objective of producing different derivative of ethylene from the ethanol obtained through the sugar cane.

In Paraiba it was announced the production of 100 000 liters per day of alcohol using sugar cane as raw material.

In 1985 up to 20% of Brazilian motor fuel is planned to be obtained by means of the fermentation of the sugar cane and yucca. It is also expected to substitute all the imported oil by this way at the end of this century.

UNITED STATES

The United States have carried out researches together with Japan since the beginning of the present decade for the production of ethanol via glucose.

Such process consisted in the transformation of cellulose into sugars and its further fermentation throughout the action of yeasts.

The Gulf Oil Chemicals announced in 1977 the erection of a plant with a capacity of 315 400 l/day by this mean.

In 1978 the American Agri Fuels of Missouri stated that in 1980 a plant of 253 700 l/day would be running using different grains as raw material for the production of ethanol by fermentation.

In 1975, at the Agricultural Experimental Station in Florida the technology and the economical feasibility of the direct fermentation

method for the transformation of bagasse in ethanol and methane was studied.

In Nebraska trials were carried out in order to use alcohol mixed with gasoline.

The proposals presented to the Congress of the U.S.A. in relation with the use of alcohol in gasoline represent, an increase of 25 plants to obtain this product.

AUSTRALIA

This country studies the production of biomass and its conversion into ethanol as a strategy for being independent from the oil importation by the end of this century.

The addition of 15% of alcohol to fuel would call for the double of the quantity of lands that are used in Australia at present for the sugar production and it would represent an increase in 20 times the present installed capacity.

UNITED KINGDOM

In 1974 research works were carried out for the conversion of renewable carbohydrates into chemicals such as ethanol, acetone and butanol. Ethanol could be used for the synthesis of ethilène.

The sources of renewable carbohydrates would be straw, sawdust, waste products from food and animal processings and effluents from the confectionery industry.

JAPAN

Investigations have been planned to improve the production technology of alcohol from molasses.

This country together with Brazil has carried out some works for the alcohol continous production from starch using diastase.

THAILAND

This country is working in a project for the production of ethanol from yucca. The project included the installation of four plants, the first of them might begin to run in 1976 with a capacity of 23 300 l/day.

COSTA RICA

From 1979 on the mixture of 20% of alcohol in the gasoline consumed in the country will be iniciated. For this program the cultivating areas of sugar cane will be increased and will count on Brazilian technical aid.

PHILIPPINES

Projects have been reported in 1977 for the use of alcohol mixed with gasoline (alcogas) as automobile fuel. In order to put in practice this plan, approximately 25 new distilleries of 20 000 l/day each will be needed. The program depends on the results of the research works of the pilot plant of Negros in the Panay Area.

HAWAI

At the time studying the possibility of producing alcohol as a derivative of sugar in order to use it as fuel.

ZAMBIA

This country announced the enlargement of its production and will build up a plant with a capacity of 20 000 liters per day using molasses as raw material.

PARAGUAY

In the Department of Guaira a contract for a project of a plant of 120 000 liters/day capacity was granted to the Constructora de Destilerías Didini of Brazil. The distillery will be installed by the Administración Paraguaya de Alcoholes (APAL). The start up is expected in 1980.

OTHER COUNTRIES

Holland, Yugoslavia, Sudan, Indonesia and Bolivia have also reported researches, the enlargement of its production capacities and/or the production of ethanol from cane molasses or cereals in new plants.

WORLD PRODUCTION OF ETHYL ALCOHOL BY FERMENTATION

The greatest ethanol producers in the world are: Brazil, India, FRG and United Kingdom, all of them have productions over 2 millions hectoliters per year.

Countries such as Argentina, France, Japan and Italy have productions over one million hectoliters per year.

In Table I a summary of the reported production is presented covering the periods 1970-1978 in most cases.

TABLE I

ETHANOL PRODUCTION BY FERMENTATIVE VIA IN THE WORLD

COUNTRY	PRODUCTION hls/year	REPORTED PERIOD
Australia	745 200	77-78
Costa Rica	69 000	77-78
Martinique	28 000	76-77
Thailand	700 000	76-77
Brazil	15 970 000	77-78
Ecuador	68 400	77-78
Argentine	1 153 300	76-77
Salvador	52 600	76-77
Corea	94 300	76-77
India	5 050 000	76-77
Chile	75 000	76-77
Mexico	223 875	74-75
Dominican Republic	43 500	76-77
France	1 882 300	76-77
Jamaica	242 500	74-75
Peru	500 000	73-74
West Germany	3 500 000	73-74
Iran	74 500	66-67
Japan	1 018 800	73-74
Turkey	274 000	76-77
Belgium	203 200	69-70
Holland	506 000	69-70
Italy	1 500 000	63-64
Sweden	412 500	68-69
England	3 247 000	66-67
Norway	250 000	66-67
Switzerland	40 000	69-70

Sources: F.O Licht's International Molasses Report.
Evaluation of Cubazucar.
Evaluation of the author.

EVOLUTION OF THE PRICES OF THE ETHYL ALCOHOL

The prices of ethyl alcohol until 1973 stayed evenly. In the period between 1960 - 1973 the value was of $0.54/U.S. gallon ($175.00/ton).

As a consecuence of the oil crisis an steady increase in the price of ethanol began, the prices of the molasses followed a similar pattern and reached a value of $1.195/U.S. gallon ($388/ton) in 1977. The prices in 1976 and 1977 surpassed those attained during the II World War. In Diagram 1 the evolution of the prices of the ethyl alcohol (95^{o}GL) in the U.S. market from 1944 to 1978 are shown.

The cane molasses, one of the most significants raw materials for the production of ethanol, have been characterized by the fluctuation behavior of their prices.

In Diagram 2 the behavior of the molasses price from 1948 to 1978 is shown.

THE ALCOHOL PRODUCTION IN CUBA

At the beginning of this century 8 alcohol distilleries were in operation with a total production capacity of 20 millions liters per year almost devoted to beverages production.

With the breaking out of the II World War and on behalf of a Government Decree which forced to add alcohol to the gasoline an exponential increase in the production took place favored by the high prices of the product. The production capacity reached 210 millions liters per year in 1944.

At the end of the II World War a reverse phenomena, an exponential decrease took the production capacity to figures below 90 millions liters per year in 1948.

In 1956 the production increased again and from 1961 to 1963 the mix of alcohol and gasoline is favored again and the production ranged from 250 to 275 millions liters per year in these period.

Since 1970 the production has been generally lower than 100 millions liters per year.

The cuban ethanol production figures are shown for the period 1968-1977.

ETHANOL PRODUCTION IN CUBA

Year	l/year x 10^6
1968	208.6
1969	178.8
1970	130.1
1971	97.1
1972	106.3
1973	85.5
1974	94.7
1975	70.0
1976	76.2
1977	80.6

In Diagram 3 the behavior of the alcohol production in Cuba is shown from 1944 to 1978.

Nowaday, the alcohol industry has an annual capacity of 150 million liters per year distributed in 12 distilleries with an average capacity of 420 hl/day. The greatest plant is the "José A. Echeverría" located

in the Province of Matanzas with a capacity of 1 200 hl/day.

The production capacities of each cuban distillery are shown below.

CUBAN ALCOHOL FACTORIES

NAME	CAPACITY Hl/year
Hector Molina	153 900
Habana	81 000
Jesús Rabí	110 160
J.A. Echeverría	297 000
Melanio Hernández	145 800
Heriberto Duquesne	94 500
Enrique Varona	140 940
Amancio Rodríguez	149 040
A. Guiteras	94 500
A. Martínez	48 600
A. Colina	90 720
A. Maceo	58 050

The main uses of the ethyl alcohol in Cuba at the present time are for beverages, pharmaceuticals, cosmetics and as domestic fuel.

CONCLUSIONS

- The analysis of the last 40 years of the development of the ethanol production in the world shows 3 well defined periods which profiles are:
  a) Until the end of the II World War, the preference for the fermentation method, using the carbohidrates as the main source of raw material.
  b) From 1946 to 1973, the interest went to the sinthetic ethanol using the petroleum as the source of raw material.
  c) From 1973 until now, the reverse tendency favors the fermentation method, again searching for new non-conventional, renewable source of raw material to obtain an alternative source of fuel.
- The prices reached by the ethanol since 1973, surpassed the ones attained in the II World War.
- Brazil started an ambitious plan to reach considerable increases in the ethanol production and utilization mixed with gasoline and without mixing for energetic installations.
- Various sugar producing countries are conducting, at different stages, studies in order to increase their ethanol production capacities from the sugar cane and/or its byproducts.

- The interest in the development of new ways of producing ethanol by fermentation from carbohidrates include developed and developing countries as well.
- The alcohol industry was the first industry of the byproducts of the sugar cane developed in Cuba.
- Nowaday Cuba has an installed capacity of 150 millions liters per year of ethanol by fermentation distributed in 12 factories over the country.

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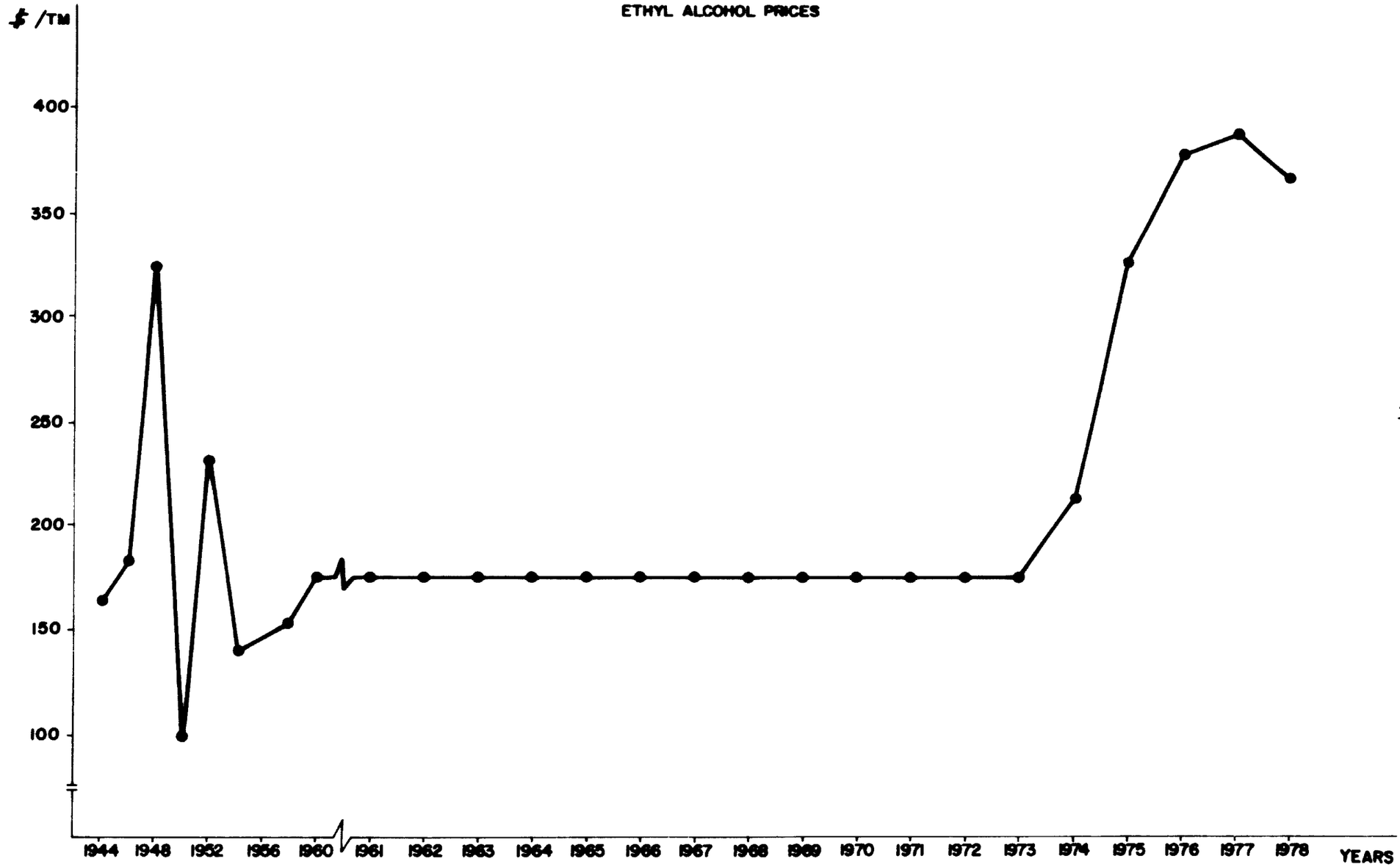
DIAGRAM 1

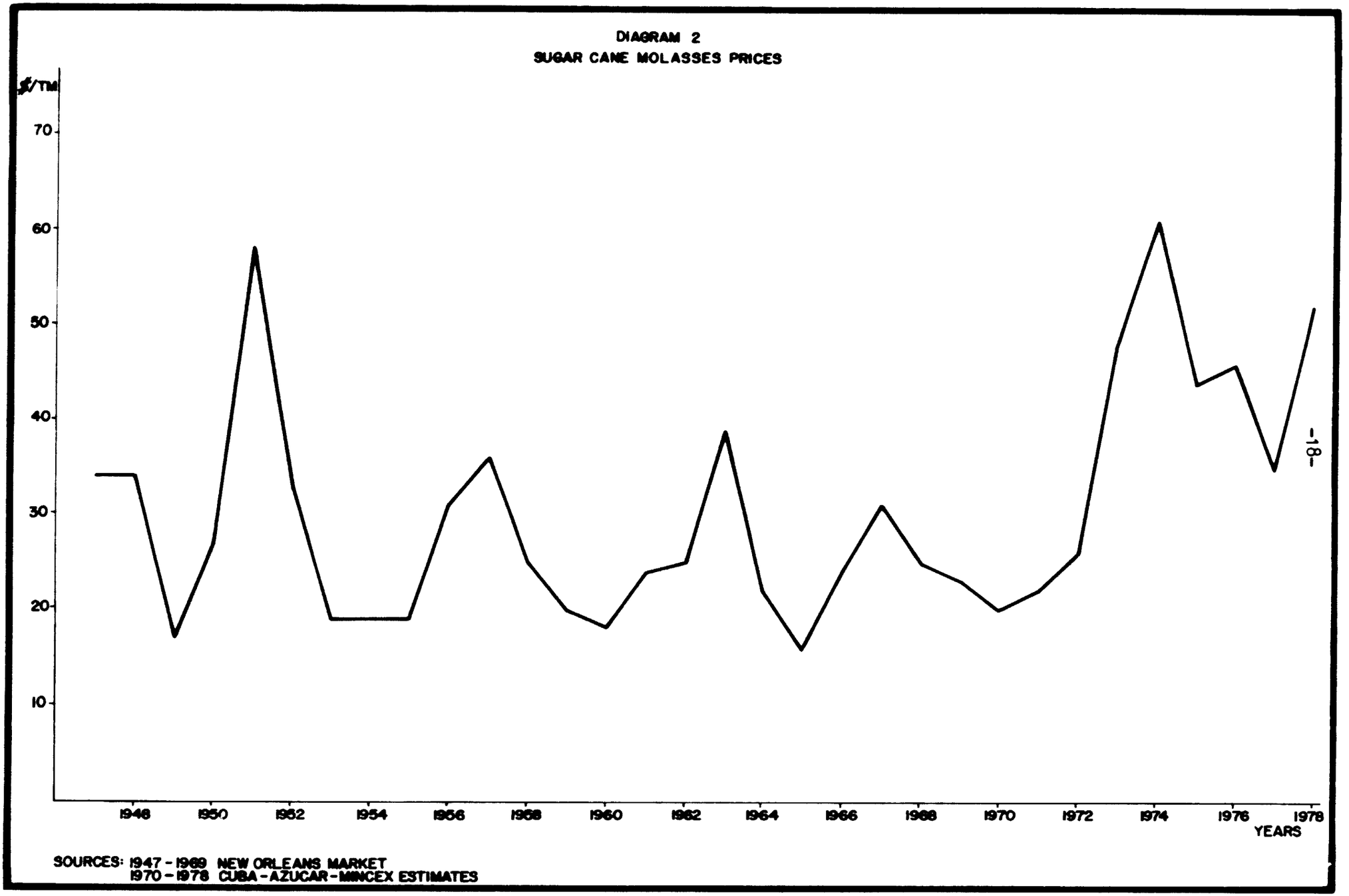
ETHYL ALCOHOL PRICES



SOURCE: CHEMICAL MARKETING REPORTER.

DIAGRAM 2

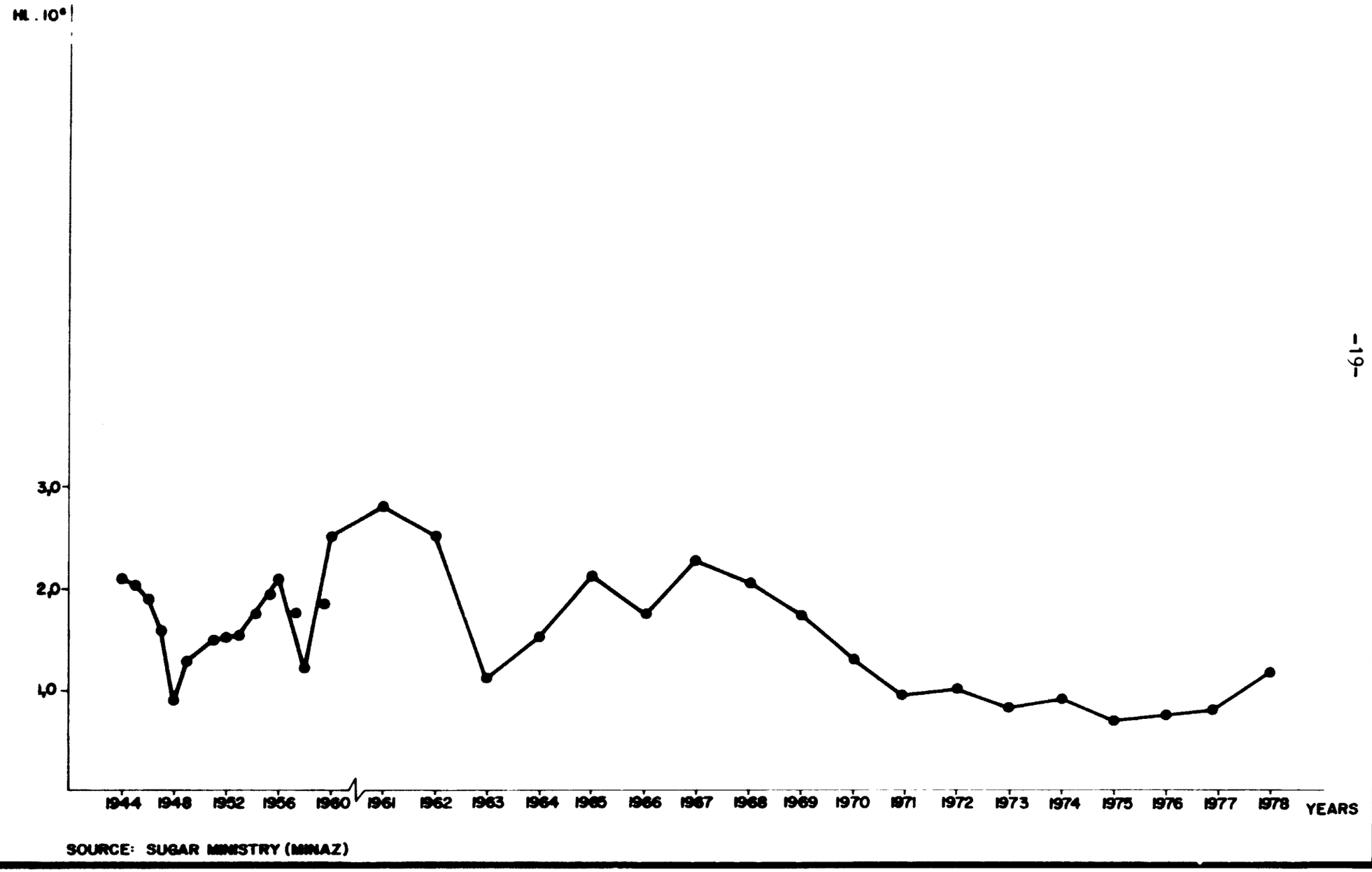
SUGAR CANE MOLASSES PRICES



SOURCES: 1947 - 1969 NEW ORLEANS MARKET
1970 - 1978 CUBA - AZUCAR - MINCEX ESTIMATES

DIAGRAM 3

CUBAN ETHYL ALCOHOL PRODUCTION



SOURCE: SUGAR MINISTRY (MINAZ)

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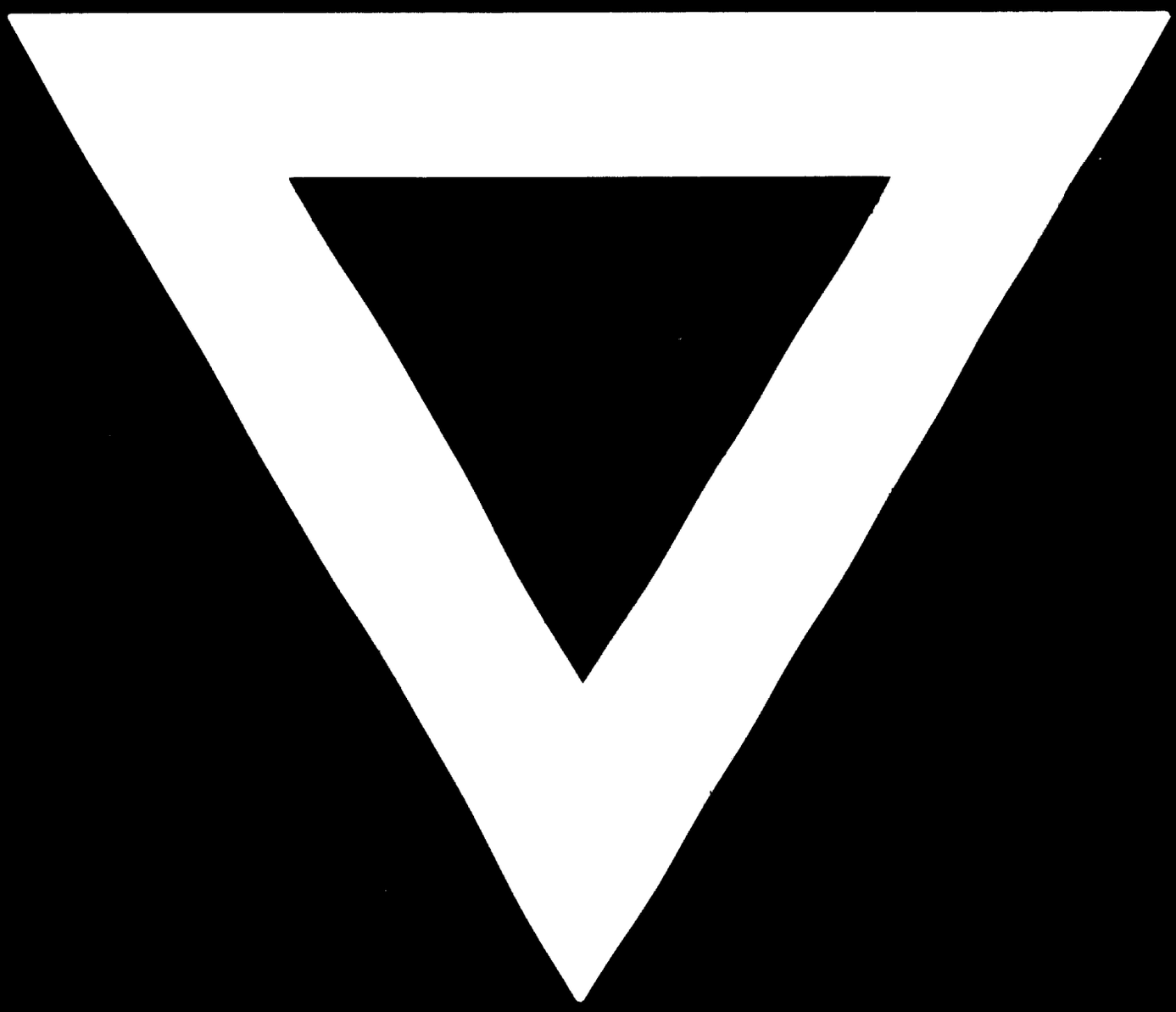

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