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Fuel and Chemical Feedstock in Developing Countries

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# ASPECTS OF FERMENTATION ALCOHOL PRODUCTION*

by

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## Introduction

According to the progress of the Brazilian National Alcohol Programme, similar projects to manufacture fermentation alcohol from agricultural and renewable resources are being considered all over the world. Most of the alcohol thus produced is to be utilized as a substitute of motor fuel by mixing it with gasoline, but some of it is presumed to be directed to chemical industry as a starting raw material for ethylene.

While these projects are prevalent in developing countries, developed countries, like the United States, consider them also as a counterplan for energy security.

The topic of this workship is very much appropriate as it is known that OPEC will raise oil price again by some 15% during 1979.
We, KYOWA HAKKO, are the biggest fermentation alcohol producer in Japan and it is our greatest pleasure if our actual experience will contribute to the topics of this workshop.

## Fermentation Activities of KYOWA HAKKO

We, KYOWA HAKKO, do not only manufacture alcohol but also many other fermentation products, such as mono-sodium L-glutamate (food flavor enchancer), L-lysine (essential amino acid for animal growth), baker's yeast, antibiotics and enzymes as shown in Table 1.

These products are made from cane molasses imported from South-East Asian countries. The quantity of molasses consumed by us amounts to 200,000 to 250,000 tons per annum, which corresponds to approximately one fifth of the total consumption in Japan. Such huge consumptions of molasses will inevitably cause effluent problems.
We convert the waste by our own process to an organic compound fertilizer totalling about 140,000 tons per annum. Our principle is that the valuable residual ingredients of molasses fermentation mashes are to be returned to the soil. We are confident that such a fermentation complex has never been practised in the world.

## KYOWA HAKKO's Activities in Fermentation Alcohol

As previously described, we manufacture about 70,000 kl of pure potable alcohol by fermentation. Our experience over more than 30 years operation and our potential can be characterized as follows:

1. fermentation processes to various kinds of feedstock such as molasses, corn, tapioca tip, rice and sweet potato;
2. large fermenters can be designed and are available;
3. compact distillation systems can be applied, especially for anhydrous alcohol production;
4. energy saving process;
5. waste treatment system is available.

According to the above mentioned features, the following index can be expected by KYOWA HAKKO's alcohol production process as shown in Table 2.

## Advantages and Disadvantages of Various Feedstocks

Various feedstocks are available for alcohol production by fermentation; their advantages and disadvantages are as follows.

Cane juice : bagasse can be utilized as fuel source;
operation is restricted to harvest season.

Molasses : Price may be the cheapest;
operation and handling are easy;
trouble may occur through scaling.

Corn/Tapioca: Saccharification is inevitable;
extra facilities and enzymes are required;
operation throughout the year is possible;
high energy requirement.

Very careful feasibility studies are required to determine the most suitable feedstock for each district.
In general, cane juice and/or tapioca seem to be the most suitable feedstock from the view point of both alcohol production and agricultural development.

## Energy Requirement

The most important fact to be considered for manufacturing an energy substitute such as anhydrous alcohol is to reduce the process energy as much as possible.

We have estimated the energy requirement for upgrading various kinds of feedstock into ethanol.

Cane juice and molasses require about 300 Kg of bunker oil and corn or tapioca require about 700 Kg of oil per kl of alcohol. In the latter case, fairly large amounts of oil are required for liquefication and saccharification.

The most economical process from the point of view of energy consumption is cane juice fermentation, because the whole energy requirement of the process can be provided by the bagasse which is produced by the milling section from about 25% of the cane delivered into the plant. On the contrary, a large quantity of external energy has to be supplied in the case of corn or tapioca. For alcohol production from manjoca (tapioca) in Brazil, it is said that about 5 tons of wood are required for the production of 1 kl of anhydrous alcohol. In the case of corn or tapioca, with a requirement of about 700 kg. of oil per kl of anhydrous alcohol much more energy is consumed than made available.

## Productivities per Unit Area of Arable Land

As it is supposed that plantations will inevitably be required for the planning of the anhydrous alcohol project in most of the countries, the choice of the most effective plant crop suitable for each district will be the key problem from the economical view point.

The harvest per unit area for each crop is shown from statistics published from FAO and the possible quantity of alcohol corresponding per unit area is also shown in the same table.

| Crop | Harvest (tons/ha) | Alcohol (kl/ha) |
|---|---|---|
| Cane | 54.4 | 3.6 |
| Corn | 2.8 | 1.1 |
| Tapioca | 9.0 | 1.4 |

The above figures, the required field area for the production of 10,000 kl of alcohol per annum are estimated as follows:

| | |
|---|---|
| Cane | 2,800.ha |
| Corn | 9,100 ha |
| Tapioca | 7,100 ha |

The most advantageous crop for alcohol production is likely to be sugar cane. Considering the low international price of sugar, exploitation of existing cane fields could be directed towards alcohol projects.

## Manufacturing Cost Estimate for Anhydrous Alcohol

The factors which influence the manufacturing cost are as follows:

1. Price of feedstock.
2. Necessity of external supply of energy and its price.
3. Investment for production facility.
4. Method of depreciation.
5. Interest.

Although those figures will differ in the various countries by their circumstances such as agricultural structure, labour conditions and fiscal background, some typical figures on the manufacturing cost of alcohol are shown in Table 3.
The reason of the highest cost in the case of cane juice are as follows.

1. Rather high investment is required for the milling and the utilities sections.
2. Plant operation is restricted to the harvest season resulting in a heavier burden of fixed cost.

But if we consider the area of the plantation, alcohol from cane seems much more realizable than that from cassava.
On the contrary, much more employment opportunity will be created in the case of cassava than of cane_
So it is very dangerous to judge the viability of the project simply from the comparison of the manufacturing cost of the product.

Treatment of Stillage

The treatment of industrial effluent is now becoming of prime importance for the protection of the environment. As stillage contains a rather high BOD, several processes are amenable for its treatment, such as lagooning, concentration, incineration or anaerobic digestion.
KYOWA HAKKO have developed a technology to manufacture an organic compound fertilizer derived from molasses fermentation waste.
The process comprises the following procedures: concentration, acid treatment, neutralization, kneading and granulation.
The blook flow diagram is briefly shown in Figure 1.
According to this process, KYOWA HAKKO is now manufacturing about 140,000 tons of organic compound fertilizer annually which is called "Complehumus". The fertilizer has been highly appreciated by the Japanese farmers and some of it is exported.

Suggestions to Developing Countries

The investment for alcohol production will require several million dollars even in the case of utilizing molasses which seems to be the most favourable feedstock. Further investment will also be required for the plantation project to obtain carbohydrate used as a feedstock.

Such huge investment would be a heavy burden on the finance of the developing countries. For this reason, we would like to suggest to install a small size demonstration plant at first for the realization of the anhydrous alcohol project.
The demonstration plant would be operated to investigate the following items.

1. Selection of the most suitable carbohydrate locally available.
2. The establishment of the process according to the carbohydrate selected.
3. Recovery experiments regarding by-products,
4. Selection of the most suitable waste treatment process.
5. Training of personnel.
6. Experiments using anhydrous alcohol, such as road tests.

We currently estimate that such a demonstration plant could be installed for about 1 to 2 million dollars of investment.
We, KYOWA HAKKO, willingly cooperate to realize such a project in any country at any time.

TABLE I FERMENTATION COMPLEX BY KYOWA HAKKO

| | | |
|---|---|---|
| ETHYL ALCOHOL, POTABLE | | 70,000 kl /YEAR |
| MONO SODIUM L-GLUTAMATE (FOOD FLAVOR ENHANCER) | | 15,000 TON/YEAR |
| L-LYSINE (ESSENTIAL AMINO ACID FOR ANIMAL GROWTH) | | 12,000 TON/YEAR |
| BAKER'S YEAST | | 3,000 TON/YEAR |
| ANTIBIOTICS | MITOMYCIN C<br>SPIRAMYCIN | FAIRLY LARGE AMOUNT IS PRODUCED |
| ENZYMES | CELLULASE<br>ASPARAGINASE | VARIOUS KINDS OF ENZYMES ARE PRODUCED |
| ORGANIC COMPOUND FERTILIZER | | 1[illegible]0,000 TON/YEAR |

TABLE 2 INDEX FOR ANHYDROUS ALCOHOL PRODUCTION BY KYOWA HAKKO

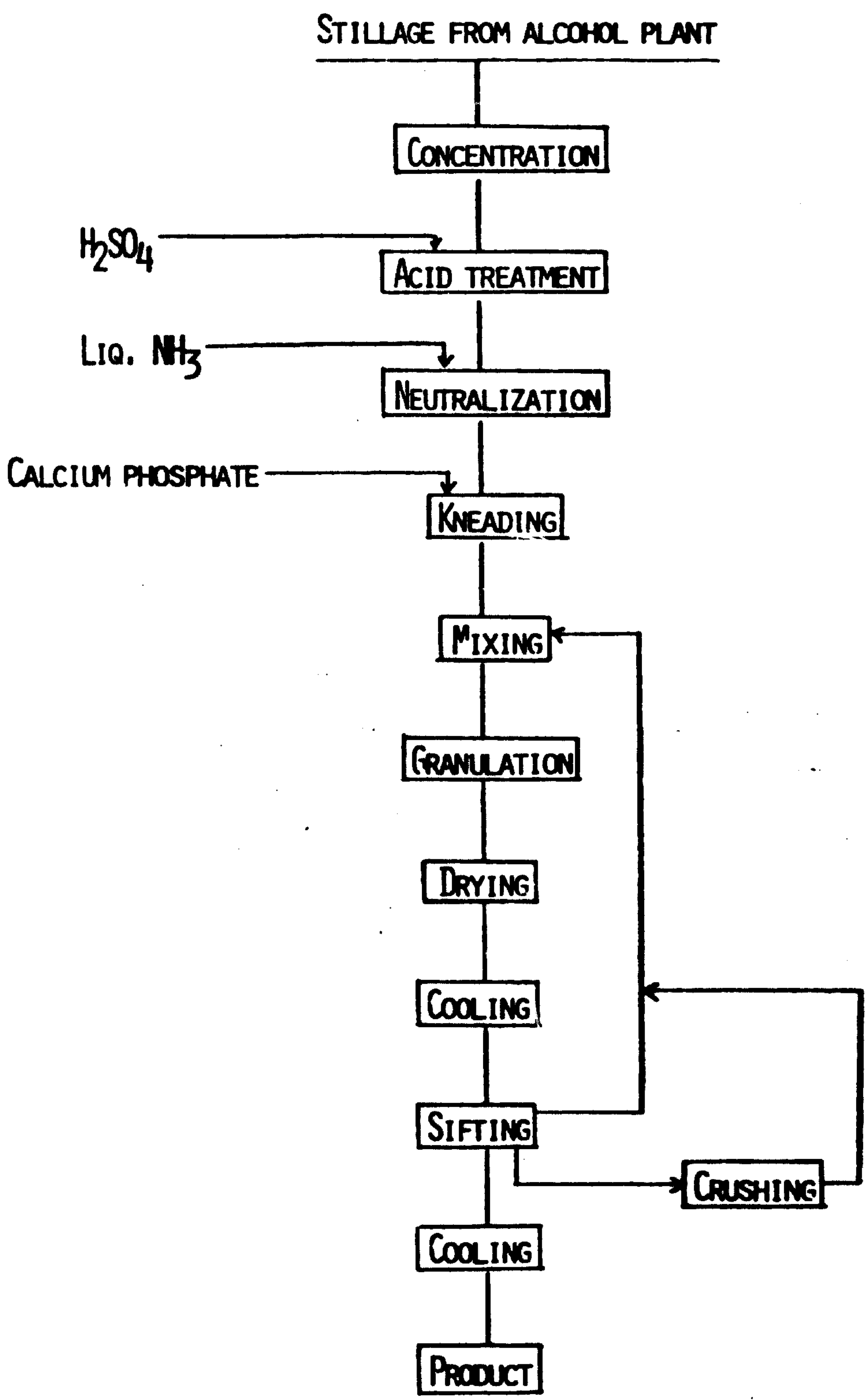
| | CANE JUICE | CANE MOLASSES | CORN | TAPIOCA |
|---|---|---|---|---|
| CARBOHYDRATE | 13 TON | 3.5 TON | 2.6 TON | 6.3 TON |
| STEAM | 3.5 TON | | 8 TON | |
| ELECTRICITY | 100 KWH | | 200 KWH | |
| WATER (26°C) | 250 kl | | 350 kl | |

NOTE: ALL FIGURES ARE SHOWN BY THE REQUIRED QUANTITY FOR 1 kl OF ALCOHOL PRODUCTION.

## TABLE 3 ESTIMATED MANUFACTURING COST FOR ANHYDROUS ALCOHOL

| | MOLASSES | CANE JUICE | TAPIOCA |
|---|---|---|---|
| PRICE | $ 20/TON | $ 10/TON | $ 25/TON |
| UNIT PRICE PER 1 kl ALCOHOL | $ 70 | $ 130 | $ 158 |
| FUEL PER 1 kl ALCOHOL | BUNKER OIL 0.3 TON | | WOOD 5 TON |
| INVESTMENT (60 kl/DAY) | $ 5 TO 6 M. | $ 14 TO 16 M. | $ 6 TO 7 M. |
| OPERATION | 300 DAYS | 150 DAYS | 300 DAYS |
| DEPRECIATION | 10 % | 10 % | 10 % |
| INTEREST | 10 % | 10 % | 10 % |
| APPROX. MANUFACTURING COST | $ 210/kl | $ 450/kl | $ 300/kl |
| NOTE | WASTE TREATMENT INEVITABLE | REQUIRED PLANTATION 2,500 HA | REQUIRED PLANTATION 13,000 HA |

FIG. I BLOCK FLOW DIAGRAM OF KYOWA's ORGANIC FERTILIZER



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