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UTILIZATION OF THE SUGAR CANE PLANT

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Introduction

The history of the sugar industry from its earliest development has been one of greatly fluctuating fortunes. It is probably one of the largest tropical agro-industries that is practised on a worldwide scale and hence the effect of these fluctuations on the economies of the developing world has been particularly damaging.

This cycling effect of world sugar prices has from time to time persuaded the producing and importing countries to attempt to control the fluctuations through an International Sugar Agreement. However, this has not been entirely successful as neither all of the exporting nor all of the importing countries ever signed these agreements in full, resulting in a collapse of the Agreement whenever a serious stress on the market came about. This has been partly compensated for by short-term bilateral agreements - between an importing and an exporting country - which have generally accounted for the majority of the world sugar trade.

The interest in by-product utilization within the sugar producing countries has closely followed the cyclic effect of world sugar prices, with little or no interest being shown by sugar producers in the years when the price of sugar was high. This sporadic interest in by-product development, coupled with the fact that, in general, the facilities for sophisticated research necessary for this development are situated, in the main, in the developed countries, has led to the situation where by-products play a very small part in the economic structure of the industry today.

Present Sugar Situation

The most important occurrence in the sugar world in 1977 was the successful negotiation of a new International Sugar Agreement which came into force on 1st January 1978 and which, we hope, will have a stabilizing effect on the world sugar trade.

1977 opened with the London daily sugar price at £112.6 per ton which soon fell to £107. It improved to £151 on the 25th April 1977 and thereafter steadily declined to reach a new low level of £85 by 9th November. The new agreement has established a price range of 11 to 21 cents (US) per pound of raw sugar f.o.b. When prices are in the lower part of the range or below the range, control will be exercised by the quota mechanism while, if prices are in the upper part of the range or exceed the range, control will be exercised by the release of Special Stocks. The large and medium exporters will be controlled by quotas which will be set at percentages of basic export tonnages. The basic export tonnage for the first two years of the agreement has been settled at a total of 15,905,000 metric tons raw value, while small exporters may each export up to 70,000 tons though it

is unlikely that many would be able to reach this figure. The above quantities are exclusive of quotas under the Lomé Convention and, in addition, a Hardship Reserve has been established amounting to 200,000 tons in the first year and 300,000 tons thereafter. This will enable temporary additional export entitlement to be granted to developing countries which have basic export tonnages or export entitlements not exceeding 300,000 tons.

Reserve stocks will be maintained at 2.5 million tons and, to assist with storage costs, a Stock Financing Fund will be established which will lend - free of interest - up to 1.5 cents (US) per pound per year in respect of sugar in store. The Fund will be financed from a levy set at 0.28 to 0.33 cents per pound on all world sugar exported from or into member countries.

Prospects for 1978

Estimates for the year 1977/78 indicate a large world sugar crop of about 91 million metric tons or 3.5 million tons more than in 1976/77. World stocks have risen to record levels and are estimated at the end of 1977/78 crop year (September - August) at around 28 million metric tons. With such large quantities of available supplies, it is understandable that one should look forward to 1978 with some anxiety. The CARICOM sugar producing countries are forecasted to produce an estimated 1.062 million tons in 1978 as compared with 950,000 tons in 1977.

Of great importance to the economy of the Caribbean member states is the signing of the Lomé Convention, in particular Protocol No.3 on A.C.P. sugar, under which the EEC has undertaken, for an indefinite period, to purchase up to 1,375,000 metric tons of sugar from the A.C.P. states at guaranteed prices. The quantities of sugar expressed in metric tons of white sugar delivered each year by individual A.C.P. states are as follows:

Barbados	-	49,300	Belize	-	39,400
Congo	-	10,000	Fiji	-	163,600
Guyana	-	157,700	Jamaica	-	118,300
Kenya	-	5,000	Madagascar	-	10,000
Malawi	-	20,000	Mauritius	-	487,200
Swaziland	-	116,400	Tanzania	-	10,000
Trinidad & Tobago	-	69,000	Uganda	-	5,000
St. Kitts	-	14,000			

Performance under the Agreement is vital to the retention of the quota. Failure to deliver the agreed quantities, other than 'force majeure', will result in the reduction of the quota to the extent of the undelivered quantities. The undelivered quantity may be re-allocated by the Community in consultation with the A.C.P. states concerned.

The above thumbnail sketch of the world sugar market clearly demonstrates the need for the Caribbean island producers, such as St. Kitts, to be seriously concerned about the profitability of sugar production at the prices to be obtained for sugar in 1978.

The development of the Caribbean sugar industry in recent colonial times was mainly characterised by the considerable subsidy given to the

industry through the Commonwealth Sugar Agreement[1] between the islands and the British Government. This method of giving aid to the dependent territories appeared, at the time, to be an ideal method since the profitability of the industry was then shared very effectively throughout the society, as sugar cane, in most of the islands, accounted for 90 per cent or more of the agricultural activity. However, this guaranteed price encouraged a general inflation of wages and a steadily increasing cost of production of sugar since each year the cost of producing sugar for the previous year was the base for the C.S.A. Therefore, under these conditions, the cost efficiency of the industry fell and, as a result, we in the Caribbean are now probably the highest cost producers of sugar in the world. The coming of independence for most of the sugar producing countries of the Caribbean, coupled with the membership of Britain in the EEC, resulted in the abandonment of the C.S.A. - leaving the Caribbean islands in a very serious financial situation. Disaster was delayed by the extremely high world sugar prices of 1974/75 which allowed the industry to survive and in some cases to be partially rehabilitated. However, the future of the Caribbean sugar industry based on the production of sugar alone must be viewed with some concern in spite of the signing of the International Sugar Agreement and the Lomé Convention.

Future Prospects of the Caribbean Sugar Industry

One of the factors that could help the industry to survive in the immediate future is the development of agro-industries based on the utilization of by-products of sugar manufacture. As mentioned before, the interest in utilization of by-products is always high when the profitability of the industry based on the sale of sugar is low. Therefore, at this time, the industry on a worldwide basis is actively pursuing this type of industrial development. However, we in the Caribbean are further constrained, and especially so in small islands like St. Kitts, by the lack of markets for the products produced from the utilization of by-products with sugar cane as a raw material base.

The By-Product Industry

The three major by-products of sugar production are: bagasse, filter mud and molasses. The utilization of these by-products is summarized below:

1. Bagasse

   (a) Direct and Indirect Utilization as Fuel
   - Electricity generation
   - Briquettes
   - Bagasse charcoal
   - Methane
   - Producer gas

   (b) Fibrous Products
   - Pulp and paper
   - Paper board, corrugating board and box board
   - Fibreboard
   - Particle board

[1] Hereafter referred to as the C.S.A.

(c) Miscellaneous Products
- Furfural
- Cellulose
- Plastics
- Poultry litter, mulch and soil conditioner
- Bagasse concrete

2. Filter Mud and Cane Wax

- Filter Mud as a fertilizer
- Filter Mud as animal feed
- Cane Wax

3. Molasses

(a) Direct Utilization of Molasses
- Exportation
- Molasses as a fertilizer
- Molasses as an animal feed

(b) Distilling Industries
- Fermentation and distillation
- Rum
- Ethyl alcohol: industrial
- Ethyl alcohol: anhydrous or absolute
- Alcohol by-products and derivatives

(c) Other Fermentation Industries
- Vinegar and acetic acid
- Butanol - acetone
- Lactic acid
- Citric acid
- Glycerol
- Yeast

(d) Miscellaneous Products from Molasses
- Dextran
- Aconitic acid
- Itaconic acid
- Monosodium glutamate (MSG)

4. Miscellaneous By-Products

- Bagasse Ash
- Protein from Cane Juice

5. Sugar as a Raw Material

- Denatured Sugar - raw sugar mixed with fish meal for animal feeding
- Surfactant - for the manufacture of detergents, etc.

From the above, it can be seen that a large amount of work has been carried out over the years on the utilization of by-products from the production of sugar.

The utilization of the following by-products would appear to be appropriate to the St. Kitts sugar industry:

1. The possibility of generating electricity, surplus to the requirements of the factory, which could then be fed into the national grid through

the Government Power Station conveniently situated alongside the St. Kitts Sugar Factory.

2. The other by-product that should be investigated for the St. Kitts conditions is the manufacture of alcohol from molasses. The feasibility of producing neutral spirit for rum manufacture and anhydrous alcohol - to be used as a supplement to gasoline - should be examined.

Whereas this utilization of by-products can improve the profitability of the industry, the production of the by-product is still dependent on the production of sugar, and the problems of selling that sugar that is produced still exists. Therefore, with the glut on the world market, disposal will continue to present a problem for several years to come.

Alternative Uses for Sugar Cane

What I have tried to look at in this paper is the utilization of the sugar cane plant for the production of products and by-products other than sugar.

It is an accepted fact that the sugar cane plant, grown in the tropics, can produce more energy per unit area of land than any other crop. It must also be accepted that in the Caribbean islands we have been successfully producing this crop for several hundred years and are probably better equipped to produce sugar cane than most other alternative crops. It is my belief that we must make every effort to diversify the use of this crop rather than diversify our agriculture away from the production of sugar cane.

When we can demonstrate other profitable uses for this fantastic plant, it will give us a great advantage when negotiating prices for sugar with the developed importing countries, since the sugar cane plant may be turned into alternative products allowing us to adjust our production of sugar and hence the price on the world market.

The development of industrial utilization of sugar by-products such as bagasse, filter mud and molasses could go some way towards alleviating the economic stresses on the industry. However, the use of by-products of sugar still includes the necessity of producing sugar, accompanied by the problems of marketing. The real hope for the betterment of the industry lies in finding alternative uses for sugar cane.

The new Separation Technology seems to hold out the greatest hope for the integrated use of the sugar cane to produce many different products. The use of the fibre portion of the plant for the manufacture of boards and structural materials appears to be the development with the highest economic viability. The use of this technology to subsidize the production of products from other parts of the sugar cane plant will lead to further development towards total utilization of the plant.

Economics of Separation Technology

One of the most economically feasible methods of diversifying within the industry is through the creation of fully integrated complexes using the Separation Technology to process the complete sugar cane plant. This technology was first experimented with in St. Kitts, starting some

ten years ago, and has now been perfected during the last two years.

It is obvious that there are certain economies of size that operate in a complex involving feeding animals, board manufacture and sugar or alcohol production. We shall be comparing a minimum size of 500 tons cane per day, or 20 to 25 tons cane per hour with 1000 tons cane per day or 40 to 50 tons cane per hour, allowing for some down time for cleaning and maintenance.

The cost estimates are based on plants located in the Caribbean area with a crop length of 200 days and will vary from country to country depending on individual cost factors such as price of cane delivered (which incidentally varies from US$9 to US$25 per ton), cost of energy, cost of labour, length of crop, etc.

Estimated Comparative Capital Costs of Separation Plants

	500 T.C.D.	1000 T.C.D.
	US$	US$
Equipment	660,000.00	1,320,000.00
Infrastructure & Buildings	350,000.00	420,000.00
Installation	75,000.00	110,000.00
Management & Engineering	65,000.00	90,000.00
	1,280,000.00	2,120,000.00

Estimated Operating Costs of Separation Plants

Annual Depreciation

Buildings, etc. - over 20 years	17,500.00	21,000.00
Equipment, etc. - over 10 years	93,000.00	170,000.00
	110,500.00	191,000.00
Depreciation costs per ton	1.10	0.96

Supervision & Labour

It is proposed that all management and technical staff will be shared with other operations in the complex.

Supervision daily (shared)	40.00	60.00
Daily paid labour	120.00	160.00
Cost per ton	0.32	0.22

Energy

Electricity & Fuel - cost per day	280.00	560.00
Cost per ton	0.56	0.56
Total Operating Cost per ton	US$1.98	US$1.74

The above reduction in operating costs illustrates economies of size.

Estimated Raw Material Cost (based on 1000 T.C.D. Plant)

1000 tons of sugar cane stalk are separated into 800 tons Comfith and 200 tons Comrind.

If we assume Sugar Cane Stalk at US$15/ton:

1000 tons cane @ US$15/ton	15,000.00
Cane processing 1000 tons @ US$1.74/ton	1,740.00
Total Cost	US$16,740.00

However, we have simultaneously produced 200 tons of Wet Comrind. We can now examine the effects of selling the rind at four different price levels:

Sale Price of Wet Comrind/Ton	US$12.50	US$25.00	US$50.00	US$75.00
Total Cost	16,740.00	16,740.00	16,740.00	16,740.00
Less Sale of 200 tons wet Comrind	2,500.00	5,000.00	10,000.00	15,000.00
	14,240.00	11,740.00	6,740.00	1,740.00
Value per ton of Comfith CT	17.80	14.68	8.43	2.18

Cost of Rind - Effect on Profitability of Board Manufacturing Plant

From a recent pre-feasibility study carried out by Messrs. Intercane Systems Inc. of Windsor, Ontario, Canada, in the Caribbean area, we can extract the following: 2.08 tons Wet Comrind are required to manufacture 1000 sq. ft. of ½" panel.

Raw Materials Cost - per 1000 sq. ft. of ½" panel

Purchase price of Wet Comrind	US$12.50	US$25.00	US$50.00	US$75.00
Rind	26.00	52.00	104.00	156.00
Resin	42.00	42.00	42.00	42.00
Wax	4.10	4.10	4.10	4.10
Total raw material cost/1000 sq.ft.	72.10	98.10	150.10	202.10

Processing Costs - per 1000 sq. ft of ½" panel

Electrical	11.80	11.80	11.80	11.80
Labour ¢ Supervision	17.50	17.50	17.50	17.50
Depreciation & Overheads	50.90	50.90	50.90	50.90
	80.20	80.20	80.20	80.20
Total Production Cost - per 1000 sq. ft of ½" panel	152.30	178.30	230.30	282.30
Cost per 4'x 8'x ½" panel	4.87	5.71	7.37	9.03

The retail price in one country is US$14.90 for a 4' x 8' x ½" plywood panel; allowing for a generous 45 per cent mark up the cost ex-plant would be approximately US$10.27. Profits per panel at various commercial prices are shown below:

Purchase Price Wet Comrind/ton	US$12.50	US$25.00	US$50.00	US$75.00
Price per panel ex-works	10.27	10.27	10.27	10.27
Cost per panel	4.87	5.71	7.37	9.03
Profit per panel	5.40	4.56	2.90	1.24

Since 1 ton of cane produces 3.61 panels (4' x 8' x ½")
Therefore 500 tons cane per day will give an annual production of 450,000 panels.

	US$12.50	US$25.00	US$50.00	US$75.00
Total Profits	3,989,800	3,292,320	2,093,800	895,280

Assuming a Capital Investment in Board Plant of US$3,626,000.00

Gross Margin on Capital	107.5%	90.8%	57.7%	24.7%
Equivalent cost/ton CFCT	US$17.80	US$14.68	US$ 8.43	US$ 2.18

Alternative Uses for Comfith

From the above calculations which indicate the very high profitability of a board plant based on the rind of sugar cane, it can be seen that the price of Comfith can be reduced to extremely low levels when subsidised by the rind in a totally integrated complex.

Alcohol

With the rising cost of fuel on the world market, one of the major interests in the development of by-products of sugar cane is in the field of alcohol manufacture to be used as a diluter for gasoline. The major constraint to this development has been the fact that alcohol produced from the conventional fermentation of molasses costs more than gasoline and is only used in countries where a political decision has been taken to reduce imports of petrol and to increase utilization of molasses, in which case a subsidy arrangement has been legislated. However, since in the production of alcohol, from 60 to 80 per cent of the cost is in the cost of the raw material to be fermented, it can be seen that if Comfith can be significantly reduced in price the viability of the alcohol industry can be assured; in which case the use of 100 per cent alcohol as a fuel, rather than as a 10 to 20 per cent dilutant in gasoline, may well become an economic reality.

The possibility of combining the production of alcohol with that of cattle feed appears to be feasible, provided that a partial extraction of the high quality cane juice is made from the Comfith and the juice used for alcohol production with the by-product - partially extracted Comfith - mixed with the cane tops for cattle production. However, a carefully balanced approach must be made to tying the two industries together since the scale of operation of the two industries will greatly affect the overall economies of the integrated complex.

Animal Feed - Comfith GR

The feeding of Comfith to animals originated in St. Kitts, where trials were carried out at Bayfords Dairy Farm in the 1967/68 period. Further work in Barbados, Mexico, Santo Domingo, etc. has shown that sugar cane as a source of energy for livestock production can enable tropical countries to produce intensively livestock products in the highest quality in a manner similar to that used in the more developed countries in the world and to do this at significantly lower costs.

The feasibility of producing dairy products and feedlot type beef on an intensive scale at Bayfords, Milliken, Upper Canada, etc. based on feeding sugar cane grown particularly for that purpose should be given the highest priority by the Government of St. Kitts/Nevis.

The feasibility study should investigate a vertically integrated cattle production unit aimed at making the State self-sufficient in dairy

and meat products with a possibility of supply of high quality feedlot beef to the tourist areas within the Caribbean. The study should investigate the possibility of producing the Comfith either at the Sugar Factory in association with a board complex or with a small machine situated at the farm with the rind being sold to the board complex at the Factory.

It is envisaged that the livestock complex would grow its own cane and most of the protein supplements necessary, breed its own cattle and bring in beef type cattle from Nevis for fattening, be equipped with milk and meat processing plants and market all of its products.

All cattle manure and slaughterhouse waste would be processed through bio-gas generators - hopefully producing enough methane to satisfy the total energy needs for the complex. The effluent after gas production would be used as a fertilizer for the sugar cane and protein rich crops being produced.

Sugar Production

The use of the high purity Comfith for the production of sugar was the original intention of the inventors of the Separation Process. However, the recent development of the process to produce an amorphous sugar by the direct dehydration of Comfith juice results in considerably higher yields of sugar than in the conventional process of crystallization and centrifugation, as used in the sugar factory. This higher yield, combined with low cost Comfith - produced as a by-product of the board plant - could mean that an island such as St. Kitts could produce sugar and sell it profitably, even at the bottom price of 11 cents (US) per pound, as mentioned previously as the price under the International Sugar Agreement.

Possible Uses for Comfith After Sugar Extraction

The Comfith, after sugar extraction, may be used as an absorbent since it has an extremely high surface area. It should be an ideal raw material for the manufacture of T.N.T. and other explosives. Its potential usefulness as an absorbent in the chemical and agri-chemical industries and for many other purposes where high absorbency is required is very good.

It is well known that large amounts of cellulosic material such as wood, pulp and paper and ground shell of various types are used as fillers in the modern plastic industry. Fillers are used in plastics not only to reduce the cost of the moulding powder, by replacing part of the expensive synthetic material, but also to modify, improve or introduce one or more desirable properties to make the plastic suitable for particular uses. The clean Comfith resulting from the Separation process should form an excellent filler; it should be compatible with a large variety of resins, both synthetic and natural, including phenolic, urea, cellulose acetate, cellulose nitrate and mellamine.

Comfith could also be used for the production of chemicals such as furfural, furfural alcohol, cellulose, xylose, xylitol and levulinic acid. These chemicals are at present produced from bagasse and it is expected that Comfith, being free of contamination by dirt, would be a better raw material for their production than bagasse.

Another use for Comfith is in the production of single cell protein. Work at Louisiana State University and more recently at the Caribbean

Industrial Research Institute in Trinidad on the use of whole bagasse for the production of single cell protein has shown very promising results. Because of the purity and cleanliness of the Comfith after sugar juice extraction, combined with the large surface area, it appears that Comfith could serve as a better raw material for single cell protein than whole bagasse which contains all of the hard rind fibres. The production of single cell protein could do a lot to alleviate the protein shortage so prevalent in the Caribbean.

The use of Comfith as an absorbent for molasses and urea as a feed would only be a modification of the existing technology using bagasse pith which has shown very high promise in many parts of the world.

Possible Use of the Epidermis Fraction

The epidermis fraction which is scraped off from the outside of the cane stalk in the Separation process, representing about 4 to 5 per cent of the dry matter of the stalk, contains a high quality wax in a relatively concentrated form as compared with the form normally obtainable in conventional milling, that is, from filter press mud. The recovery of this high quality wax should be greatly simplified and should fetch a fairly high price competing on the market with Carnauba wax. The epidermis may also be added to cattle feeds.

Dry Trash as a Fuel

In considering an industrial complex utilizing the whole sugar cane plant one should not forget the dry leaves or trash normally left in the field after harvest. The use of these leaves as a fuel for processing the sugar cane is now an economic possibility owing to the rising cost of oil. In Santo Domingo trash is collected in the fields, compressed into bales and burnt in the sugar mill furnace thus releasing bagasse for the more profitable conversion into furfural. Prices as high as US$20 per ton for trash have been quoted as the fuel replacement value thus making it an economic proposition to collect and transport to the mill.

Separation Technology in St. Kitts

The existence of a small prototype separation plant alongside the St. Kitts Sugar Factory could, with some modernization, utilize some of the cane being processed in the sugar factory to produce board and structural lumber to satisfy the market in St. Kitts, Nevis and the Leeward Islands. It is recommended that the feasibility of utilizing this plant should be given urgent consideration.

Summary

The economic outlook for the Caribbean sugar industry for the immediate future does not look very healthy. However, recent developments in the new Separation Technology for the processing of the sugar cane plant into products other than sugar appear to hold out some hope for an economically viable and fully integrated industry.

The author's personal opinion, therefore, is that St. Kitts should give high priority to the diversification within the sugar industry by means of development of the by-products of the existing industry and the development of means of utilizing the whole sugar cane plant to manufacture products other than sugar.