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CANE SUGAR PRODUCTION SYSTEMS: CURRENT AND FUTURE

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Abstract

Worldwide patterns of supply and demand for sugars have changed over the last fifteen years, particularly with regard to demand. The market for white sugars has increased in the developing nations, while the raw sugar market has shifted emphasis from the U.S.A. to the sugar-producing countries. Current and future production systems for raw and refined sugars are considered in light of these changes. The causes and effects of raw sugar quality, quality parameters, and processes are discussed. Systems for production of direct consumption white sugars and brown sugars are also included in this discussion.

Introduction

Production systems for sugar, as for most goods and commodities, are controlled by market requirements. There is of necessity a delay between change in demand and increase or cutback in supply to accomodate that shift. Trends in both the raw sugar and white sugar markets of the last five years have reflected those movements. The current situation is the interim picture, with supply catching up to altered demands: smaller increase in raw sugar production, and greater increase in white sugar production. The next few years should see further shifts in supply, and the production systems that generate supply, to satisfy the changing demand. It is unlikely that the system will reach equilibrium: the winds of change will initiate new waves, from new sources and in different directions. It is our ability to foresee these sources and directions, and to react to them in timely fashion, that will maintain our industry in a viable state of economy.

In South Africa, you have foreseen many new directions and the challenges that they present to the industry. You have been pioneers in agriculture, in the use of plant growth regulators and new applications of agrochemical knowledge, and in the development of modern field practices. You have led the world in producing raw sugars of the highest quality, and have changed the conditions and the language of the raw sugar market with your VHP sugars. Most recently, you have foreseen the increased demand for high quality white sugars, and have improved the quality of refined white sugar at your factories, applying and developing further the newest technologies in the refineries.

Changes in the Sugar Market, 1970-1985

Change in demand

The increased demand for refined quality white sugar has two main causes: first, as living standards improve, people eat more sugar and desire higher quality sugars. However, increase in disposable income in producer countries has slackened in the last five years, and it is more likely that the second cause has contributed more to increased consumption: the growth in food and beverage processing industries in sugar producing countries. Beverage (soft drink) companies especially, and food processing companies, and pharmaceutical manufacturers, in general require high quality white sugar for their products, and operate on a sufficiently high profit margin to purchase it, or, as a major beverage company does in South America, to process it themselves. The availability of white imports from the E.E.C. and, more recently the U.S.A., supported growth in these sugar user industries. Subsequent tariffs and regulations against imports in some producer countries have forced the user companies to look to home production of white sugars for their products.

This change in demand for white and brown sugars, and its effect on production systems, present and future, is the first subject of this paper.

In some third world countries and in socialist countries, there are additional economic factors to be considered. Foreign exchange requirements, the necessity for full employment and enforced import-export systems outside free markets have limited effects on the response of production systems to demand in these countries.

Change in white sugar market

The increase in white sugar production – including both cane and beet white sugars, is demonstrated in a graph (Figure 1) showing the relative amounts of raw and white sugars in free market trade (outside contracts such as U.S. and A.C.P.) since the early 1970's.[8] The tonnage has increased from 4,7 million tons, raw value (6,6% of total world production) in 1970 to 10,2 m.t., r.v. (10,6%) in 1983. That white sugar demand is high and continuing is demonstrated by its high premium: over $40 per ton (often over $50)* for the last several years, at times when the raw sugar New York #11 spot price has been under 3 cents. These data refer only to white sugars traded under contract, and not to those consumed in the countries of production.

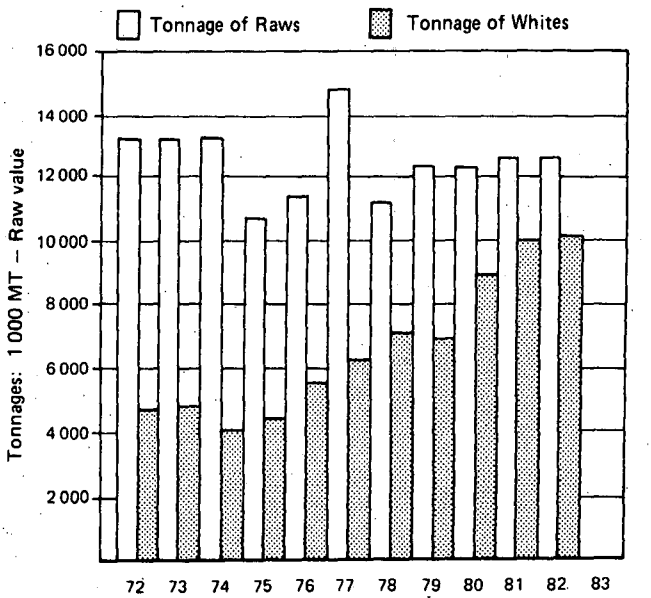

FIGURE 1 The free market evolution of white and raw sugar markets from 1972 to 1982

* all prices are in U.S. dollars

The major changes in production and consumption in the last fifteen years - from a relatively stable time of growth in the sugar world, when the U.S. Sugar Act was in operation, to the relatively gloomy picture of the mid-1980's - are outlined in Tables 1 and 2.[5] Changes in U.S. imports are outlined in Table3.[15,16] U.S. imports had increased to 6,14 million tons in 1977 before they were replaced by fructose corn syrups, produced in the U.S. Loss of the beverage market has accounted almost completely for the decrease in imported raw sugar.

Table 1

Centrifugal sugar production, raw value (1 000 tons). All figures are from U.S. Department of Agriculture Sugar and Sweetener Reports.

	1970-71	1984-85
World	70,672	101,022
North America	6,374	5,830
Beet	3,569	2,914
Cane	2,832	2,916
South America	9,131	14,731
Brazil	5,128	9,332
Colombia	689	1,354
Europe		
E.E.C.[1]	8,740	14,432
Asia	13,733	23,637
Africa	4,425	7,810
Oceania	2,839	4,158

[1] E.E.C. after 1972 included U.K., Ireland and Denmark.

Table 2

Sugar consumption, raw value (million tons). All figures from F.O. Licht and I.S.O.

	1970-71	1984-85
World	74,08	97,55
North America	11,44	8,05
Central America and Caribbean, excluding Cuba	2,76	2,20
South America	7,09	10,87
Europe		
E.E.C.	7,10	10,07
Asia	17,30	24,74
Africa	4,40	8,21
Oceania	0,97	1,00

Table 3

U.S. imports, receipts, raw value (1 000 short tons). All figures are from U.S. Department of Agriculture Sugar and Sweetener Reports.

	1970	1984
Total	5,296	(2,15 mt) 3,047
Caribbean	1,042	626
Central America	331	509
Mexico	650	-
South America	1,402	816
Brazil	667	356
Africa	35	214
South Africa	78	83
Oceania	211	288
Asia	1,453	494
Philippines	1,298	416
Usage of sugar in non-alcoholic beverages.	3,100	(2,2 mt) 900

Changes in supply

Where has this increase in white sugar production come from? A large part of it is from E.E.C. beet sugar (some 5 million tons in 1984);[17] the E.E.C. countries hope to maintain this level, although recent markets have been lost to them in sugar-producing countries. A pricing hazard is in the offing, in spite of tariff restrictions.

The rest - of more immediate interest to us - has come from cane-growing countries such as Brazil, who doubled her exports of refined sugar from 0,6 million tons in 1978 to 1,2 million tons in 1983.[15] Those cane growing nations that have refineries have increased their outputs of refined sugar: Thailand and Taiwan are examples, as is the Philippines, where one major sugar company survived the recent disturbances only because of its refining capacity. There were attempts during this time to import white sugar into the Philippines, for beverage and food processing company use. This circumstance - that a major exporter of sugar should import white sugar - has been carried further in Mexico where refined sugar is imported by the government from the U.S.A., to which, fifteen years ago, Mexico was a major exporter. The U.S. refined sugar is distributed to user companies. Some beverage companies in Mexico, unable to obtain sufficient refined sugar and forced to buy available raws to make up the difference, have installed their own sugar clean-up plants. These have contributed to the growth in technology of high quality white sugar production but are a potential hazard to future production of white sugar in these areas. The white sugar shortage to these users also presents an attractive market to fructose syrups, compounding the hazard to the sugar industry.

The U.S. is the newest exporter of white sugar: since the granting of drawback privilege on raw sugar entry tariffs four years ago, the U.S. export market has grown to almost 0,5 million short tons, and created income to continue the existence of some U.S. refining companies. U.S. refiners are on very short commons otherwise, as demonstrated in Table 3.

Other areas where the import market is increasing - the Middle Eastern countries, India (whose imports rose from export status in 1982 to almost 1 million tons in 1984, as her production declined from some 9,5 to 7 million tons), socialist countries of Eastern Europe, and other developing nations in Africa and Asia, as outlined in Table 4 - are all importing white sugar, primarily from the E.E.C. and Brazil.

Table 4

Sugar imports into certain countries (million tons). All figures are from U.S. Department of Agriculture Sugar and Sweetener Reports.

	1982	1983	1984	1985
U.S.A.	3,2	2,9	3,4	3,0
E.E.C.	2,4	2,1	2,8	2,3 est.
U.S.S.R.	6,9	5,9	5,6	5,3 est.
N. Africa	2,1	2,2	2,2	2,3
Mid-East	2,6	2,7	2,8	2,8
India	-	-	0,16	0,9

Direct production of white sugar from cane juice

Areas where sugar production is increasing are Asia, particularly China and Pakistan, North African areas and South Africa,[17] and the increase is almost all in white sugar, whether in refined white as in South Africa, or in direct production white sugar, as in Pakistan and Indonesia.

Direct production white sugar no longer means only plantation white. New technologies for production of high grade white sugar from cane juice have quickly been adopted in those same producer countries where high quality white sugar demand is highest: Brazil, Colombia, Argentina, Mexico and

Central America, Cuba and the Caribbean, Thailand, Taiwan, Malaysia and the Philippines. China is urgently applying new technology to produce refined quality white sugar for industrial users, to replace the refined sugar she currently imports from Hong Kong. Production figures are difficult to estimate, because most of this new type of sugar is consumed internally. Essentially all production increase is in white sugar in the abovenamed areas, but how much cane that formerly went to export raw now goes to direct production white is not recorded. An estimate of current production of the 8 million tons of white sugar traded on contracts in 1984 (see Figure 1), indicates that 57% was European beet sugar, 13% plantation white, 14% from independent refineries, 10% from tolling refineries, and only 6% from white-end refineries.[3] This does not include white sugar consumed in countries of production.

Current production technology

Systems for production of these direct production white sugars and white end refineries have been outlined[7] and are as follows:

1. Raw sugar for export + raw sugar for refinery attached to factory (white end refinery). Quality improvement approaches: juice clarification polymers, syrup clarification, pan aid additives, increased washing in centrifugals, and continuous centrifuges on lower grade materials.
2. Sulfitation white + raw sugar for export. Quality improvement approaches: juice clarification polymers, improved mud filtration, syrup clarification and improved pan efficiency.
3. Sulfitation white: direct production or remelt for refinery at factory. Increasing replacement with Blanco Directo systems.
4. Direct high quality white sugar production from cane juice. Quality improvement approaches: replacement of sulfitation-carbonatation with Blanco Directo or JSP systems.

Blanco Directo process

The major systems of interest are the Blanco Directo system, from Tate and Lyle, and the JSP process of the Fabcon company. These processes combine juice sulfitation and clarification wth syrup clarification to produce a sugar of colour of about 100 ICUMSA, with good visual appearance, and good keeping qualities. Properties of Blanco Directo sugar are outlined in Table 5, compared to refined white sugar and average plantation white.[4,7] This sugar is particularly suited for beverage and food processing use, because of its low turbidity. Turbidity in standard plantation whites is high and gives problems to bottlers and canners. The Blanco Directo process, with low capital investment for the factory, incorporates a clarification treatment on mud filtrate, to produce a clear sweetwater which is then sent forward to clarified juice. This step decreases turbidity by an order of magnitude, and allows the sugar to have a sparkling appearance, unlike the rather dull appearance of many plantation white sugars. The removal of polysaccharides (including dextrans) and ash in this treatment, plus that in the further clarification performed on the syrup, give increased yield of crystal sugar and allows growth of larger crystals in the same pan time as used for the smaller crystals of plantation whites. The process is versatile, in that if the factory wishes to produce regular raw sugar, sulfitation and filtrate treatment can be omitted, and the syrup clarification treatment included to produce a high quality raw.

Table 5

Comparison of various types of white sugars.

	Typical Refined Granulated	Blanco Directo	Typical Plantation White
Color (ICUMSA)	20-50	100-200	250-500
Turbidity (ICUMSA)	10-30	20-50	100-500
Ash (%)	0,01-0,04	0,05	0,1
Invert (%)	0,01-0,04	0,02	0,1
Pol	99,9	99,8	99,6
SO_2 (ppm)	-	1-2	20-50

Raw sugar quality

With regard to changes in raw sugar quality,[7] the major process factors that have led to a general increase in raw sugar quality around the world are these developed in South Africa:[1,2] attention to cane quality, use of polysaccharide-degrading enzymes, improved syrup quality, and remelt boiling systems for VHP sugars. Some of these measures were also undertaken in Hawaii, in the 1950's and 1960's, to improve their raw sugar quality.

One other major factor finding application throughout the world is syrup clarification: flotation clarification of evaporated syrup. A good description of the benefits of syrup clarification to raw sugar production, both for export and for use in the factory's own white-end refinery in Colombia, is provided by Federico Luna[13] in a paper that includes a cost-benefit analysis. Among the benefits to process are: decrease in molasses viscosity and pan and centrifugal times; production of final molasses decreased; increase in number of A-massecuite strikes and C-massecuite brix, and syrup purity increase.

Deep Bed Filtration

Another innovative process development is Deep Bed Filtration (DBF). This system, illustrated in Figure 2, operates at normal pressures, without filteraid, downflow through a bed of special granular absorbent material, to remove suspended solids and colloidal material. The filter bed material is regenerated by back-flow of syrup. This process offers good possibilities as an additional separation and purification after clarification with minimum equipment and recycling, for white sugar production in white-end refineries or raw sugar clean-up plants. Initial data from S.P.R.I. indicate that Deep Bed Filtration is also effective at removing polysaccharides from raw sugar syrups.

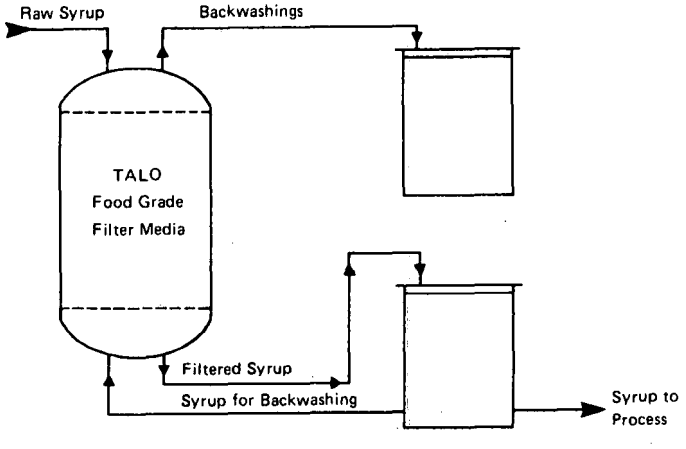

FIGURE 2 The Deep Bed Filtration process

White-end refineries

The increase in white sugar production through white-end refineries has increased the interest in quality and altered the point of view of factories owning these refineries. The decrease in refining costs from improved quality of raws becomes apparent at first hand, as is shown in Luna's paper.[13]

One direct result of these refineries on the quality of raw sugars produced at their factories is mixing of low grade run-off syrups from the refinery with evaporator syrup going to raw sugar pans. This can lead to a buildup in non-sugars, concentrated in refinery pan run-offs, and recycled back through to raw sugar. Soluble polysaccharides can be included in these non-sugars. A syrup clarification system can help to remove some of these non-sugars and prevent buildup of non-sugars from the refinery.

Direct consumption brown sugars

There is a small, but growing and profitable, market for direct consumption raw sugar, for brown raw sugar, mostly in the U.S. and the U.K. These sugars, sold under various fabricated names often including "raw", are for the most part well washed raw sugars, usually dried in a rotary dryer, and packaged in the country where they are sold. Some are shipped packed in the country of consumption, as for example, a 500 g pack of "Muscovado" raw sugar from Malawi, which the author obsrved for sale in the United States at a price of $4,50. The world price of raw sugar was under 64 at the time.

Many of these sugars (almost certainly not the "Muscovado", however) are made at factories using syrup clarification, so that the sugars have a sparkling, crystalline appearance, and do not create a lot of turbidity when dissolved in liquid.

Future developments

With overproduction of raw sugars decreasing only slowly, and no relaxation of penalty systems in sight, the emphasis on production of high quality raws is likely to continue. As factories optimize their current processes for maximum efficiency and improve cane handling and delivery systems for highest sugar recovery and lowest non-sugar levels, there will be renewed interest in improved systems of production. As the product price level increases (the New York #11 Spot price doubled between July 1985 and March, 1986), further investment can be expected, especially in clarification and filtration systems described above.

New technologies – still at the research or pilot level that look attractive include membrane technologies: electrodialysis for deashing;[10, 19] reverse osmosis for juice concentration,[5, 11] and ultrafiltration,[9] which is already in operation in Australia for desalting of molasses.[18] The possibility of continuous amorphous sugar production,[14] especially from juices cleaned up by some of these new membrane technologies, may be in future sugar production technology: the combination has low energy demand, releasing more bagasse for cogeneration, and only one processing byproduct, that can be sold as a feed additive. Combinations of membrane technologies with ion-exchange systems could produce either brown or white sugars.

This paper began with a consideration of market effect on production facilities. It has emphasized the increasing production of, and market for, white sugars, and the new technologies that have evolved for direct production of high quality white sugars.

In conclusion, let us consider the effect of production systems on the market. We have seen that the industry has increased production of white sugars for profitability. How long can we expect the white sugar margin to hold high enough to maintain investment in new facilities? Fundamentalists will say: as long as it takes supply to catch up with demand.

We are technologists rather than market theoreticians, and we can see in the increased demand for white sugars opportunities to develop new products, and new production systems, and improve efficiency and product quality in the cane sugar industry.

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