SUGAR IN INDUSTRY

By A. M. HOWES

Sugar has been described appropriately, and elegantly, by an old Hindu philosopher as "The Life-Giving Energy of the Sun". It has also been estimated, perhaps conservatively, that sugar provides 10% of the energy intake of the world's population.

In times of world demand, rapid expansion and increasing annual tonnages, there would appear little need or desire to divert one's attention from the major preoccupation of producing "the best sugar in the world". It is indeed at these times when some consolidation is necessary to ensure the stability of our markets, particularly the South African market, that we must study and be familiar with the uses of sugar and the consumer's requirements.

The South African Sugar Association recently established a Market Research Committee to perform this function and to promote sugar by-products, modified sugars, and sugar derivatives. It should not only provide a service to the industrial consumer, but also create new outlets for sugar, particularly in times of surplus.

Compared with direct domestic consumption, the use of sugar in South African industry continues at a low level, this is even more apparent when comparing the rate of industrial sugar consumption in other countries.

TABLE I

Industrial Sugar Consumption % of Total

COUNTRY	1951 % of Total	1963 % of Total	INCREASE
Australia	47	54	7
New Zealand	26	40	14
Mexico	20	29	9
U.S.A.	44	63	19
South Africa	19	21	2

The reasons for this slow rate of development surely concerns every one of us, and in particular, a market research team.

Other sweeteners used by Industry are Corn Syrup, Dextrose and the more recent synthetic non-calorie substitutes — saccharin and cyclamate (sodium or calcium cyclohexyl sulphamate). The latter, in particular, has penetrated the American beverage industry to the extent of 8% of the total sweeteners used. Should this be tolerated in the Republic it would be quite contrary to the best interests of national health as the major portion of the population consists of Bantu who are hardly concerned, consciously or otherwise, with a reduced calorie diet.

The total population of the Republic on the 30th June 1964 was 17,473,000, consisting of the following racial groups:

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European	3,335,000	19%
Coloureds	1,703,000	10%
Asiatics	520,000	3%
Bantu	11,915,000	68%
TOTAL	17,473,000	

Glucose syrup is now being supplied in bulk to consumers on the Reef by road tanker. Both glucose and dextrose are produced by an industry consuming 80,000 tons of maize per annum out of a total annual maize crop of 6½ million tons per annum. 50% of this crop is exported.

Although the use of non-calorie sweeteners in South Africa is small its equivalent in sugar amounts to some 3,000 tons per annum. We therefore cannot afford to ignore the trends in other countries.

In 1962 the American consumption per capita of synthetic sweeteners was 2.4 lb., corn sweeteners 17.8 lb., and sugar (both cane and beet) 96.7 lb., a total of 116.9 lb.

Between 1962 and 1963 the industrial consumption of synthetic sweeteners increased by 20% in equivalent sugar, while domestic consumption increased by 16%.

TABLE 3

Total U.S. Sweetener Consumption, 1962/3

	1962	1963	EQUIVALENT SUGAR (IN TONS) 1963
Synthetics	2.5%	4.5%	270,000
Corn Sweeteners	20.2%	22.2%	1,560,000
Sugar	77.3%	73.8%	9,140,000

Corn sweeteners recorded a 10% increase in industrial consumption but dropped by 10% in the domestic market. A noticeable feature about the total sugar consumption of the American citizen is his steady capacity for sugar — it has not veered from 96-98 lb. per capita per annum since 1922.

Table 4, line four, reveals the healthy tendency of his South African counterpart, the traditional tooth is getting sweeter but has not yet reached the American standard. This may lead us to believe that the Bantu population of 68% is still content with the direct consumption of sugar until his purchasing power allows him to enjoy the processed article. We might then expect that soon after the total consumption has reached 97 lb. per capita, the industrial use of sugar should increase and overtake the domestic consumption in accordance with the general overseas trend.

TABLE 4

Five Year Average

	1941-45	1946-50	1951-55	1956-60	1961-65
Population	12,275,800	13,312,200	14,600,800	16,068,000	17,473,000*
Increased	—	8.44%	9.68%	10.05%	8.04%
Total Sugar Consumption	440,923	530,692	593,489	718,073	798,554*
Per Capita (lbs.)	71 83	79.73	81.30	89.34	91.40
Manufacturers' Consumption	82,070	96,879	112,111	142,015	165,194
% of Total Consumption	18.6	18.3	18.6	19.8	21.0
Per Capita (lbs.)	13.37	14.55	15.36	17.68	18.91

*Estimated.

Sugar Used by South African Industry

In the year 1963/4, the quantity of sugar used by the food industry amounted to 167,709 tons, of which the canning industry consumed a substantial third.

TABLE 5

Industry	Sugar (tons)	% of Total Sugar
Canners	56,952	34 0
Confectioners	32,334	19.3
Beverage	29,904	17 8
Sundry Manufacturers	20,496	12 2
Dairies	16,810	10.0
Bakeries	8,697	5.2
Golden Syrup	2,516	1.5
	167,709	100.0

Of the total 275,500 tons of canned food produced, 154,000 tons consisted of fruit and 65% of the total was exported.

The confectionery trade is the largest consumer of glucose, amounting to 40% of the total sweetener required. Both the mineral water and ice cream industries share the balance of the commercial glucose consumed by the food industry.

An indication of the total sugar content of standard food products is given in the following list:

Commodity	% Sugar
Jelly powder	90
Syrups	85
Jams	65
Condensed milk	45
Squashes	35
Cakes and Bakers' confectionery	28
Biscuits	24
Canned fruit	17
Beverages	10
Canned vegetables	6
Canned fruit juice	3
Bread	0.4—1.2%

Both the canneries and the dairies require a high degree of bacterial control, for this purpose a thermophile free "Canners' " sugar has been produced at Hulsar by subjecting the sugar to ultraviolet ray treatment.

A brief glance at the results of a survey conducted in 1962/63 in the nine main centres of the Republic on the sugar content of bread provides food for thought. Perhaps distance from the Sugar Industry makes the heart grow fonder (of sugar), with the exception of Johannesburg.

Centre	Bread Produced (Tons)	Sugar Content (Tons)	Per-cent
Port Elizabeth & East London	33,093	393	1.19
Cape Town	79,915	785	0.98
Bloemfontein & Kimberley	16,181	145	0.90
Pretoria	36,836	290	0.79
Durban & Pietermaritzburg	77,252	418	0 54
Johannesburg	136,045	492	0 36
Rest of S. Africa	210,276	1,892	0 90
	589,598	4,415	

These sugar contents are surprisingly low when compared with the rapid rise of sugar used in bread in the United States. (*Sugar Information Inc., N.Y., March*, 1954).

Sugar Usage in White Pan Bread

Year	Percent
1920	2.0
1925	3 0
1930	4.0
1935	5.0
1939	6 0
1943	4.0
1947	6.0
1950	7.0
1952	8.0

Thus the use of sugar in 1952 was up as high as 8%. At this level laboratory tests have shown that 2.3% was used in the fermentation leaving 5.7% as Dextrose and Levulose, while at an initial sugar content of 3% only, 1.08% remained as invert sugars with the Levulose providing the greater proportion of sweetness.

The relative sweetness of various sugars are compared with sucrose rated at 100:

Sugar	Sweetness Rating
Levulose	128
Sucrose	100
Invert Sugar	99
Dextrose	69
Glycerol	75
Mannitol	69
Sorbitol	51
Maltose	40
Lactose	39
Dextrine	5
Synthetics:	
Saccharin	30,000
Cyclamate	3,000

Liquid Sugars

The liquid sugar industry in America has developed rapidly since 1945 to a magnitude of 2½ million tons in 1963, of which the beverage industry consumed more than 50%.

The term liquid sugars covers a wide range of liquors from 67 Brix pure sucrose to 77 Brix total invert syrup, and blends of corn syrup with both sucrose and invert sugars.

Due to the high cost of transport between the less densely populated areas in South Africa, liquid sugars have not yet proved an economic proposition. However, the higher concentrated invert sugars and syrups have established markets in the Republic.

Invert Sugar

Invert sugar occurs naturally in ripe fruit and is the major component of honey. It is prepared commercially from sucrose either by ion-exchange, enzyme or acid inversion, to an equal mixture of dextrose and levulose.

In the first mentioned method the liquid sucrose is passed through two ion-exchange beds in succession; initially through a cation bed which lowers the pH causing the sucrose to invert, and then through the anion bed which raises the pH and completes the process.

When using enzyme action on liquid sucrose careful temperature control is necessary during inversion which, in turn, is suspended by raising the temperature sufficiently to kill off the enzyme.

In both the above methods there is little or no addition of flavour compared with acid inversion which contributes a variety of flavours depending on the type of acid, the quantity and temperature. Both pH and temperature being essential process controls in determining inversion rate.

During the inversion a molecule of water combines with sucrose, which divides equally into two monosaccharides, thus increasing the total sugars by 5.26% and in doing so the plane of polarised light is "inverted" from dextro to levo-rotation due to the stronger influence of the levulose — hence the word "invert sugar".

Dextrose and levulose are found in varying quantities in a number of recognised sweeteners. Nulomolene is a fully inverted creamed sugar, similar to a smooth crystallised honey, which has found application in the Baking, Tobacco and Textile Industries, in the latter as a plasticiser and a moisture retainer.

Fondants, treacle syrups and, of course, golden syrup all contain invert sugar. The last mentioned being the aristocrat of invert syrups by virtue of its characteristic flavour, colour and brilliance.

Properties of Invert Sugars

Due to its relatively high solubility, invert sugar is used as a "doctor" in the confectionery industry to inhibit crystallisation. Because of this higher solubility, invert syrups possess a high osmotic pressure which inhibits fermentation caused by the growth of yeasts or moulds.

An additional useful characteristic of invert sugar is its humectant property, that of moisture retention. From Equilibrium Relative Humidity (ERH) measurements made by R. S. Norrish of the Sugar Research Foundation on "humectant" substances, the weight humectancies were calculated to be in the order: Glycerol > Sorbitol and Invert Sugar > Sucrose > 42 DE Glucose. The effects of Invert Sugar and Sorbitol are not significantly different although they are appreciably better than sucrose, which in turn is slightly better than glucose.

This humectant property is perhaps most useful to Bakeries who take pride in promoting the shelf life of both their bread and cakes by ensuring this moisture retention.

Caramel

Although one of the main functions of the Refinery is to remove colour from raw sugar it is now concerned through George Clark and Son in making colour from refined sugar and "a little goes a long way"!

Caramel colour, known as "burnt sugar", "sugar colouring", "Black Jack" or "Saccharum Usstum" is a black viscous liquid used on occasions as a flavouring material, but essentially for imparting the characteristic, and natural, brown colour to a wide range of food products.

TABLE 6

Products Using Caramel

Foods	Beverages	Other
Gravy browning	Cola drinks	Soap
Sauces	Beer	Tobacco
Canned meat	Vinegar	
Canned soup	Brandy	
Essences (coffee)	Rum	
Extracts (meat and fruit)	Wine	
Mincemeats		
Biscuits		
Christmas Puddings (cakes)		

Caramel may be manufactured either from sucrose or from glucose. A more uniform colour development and caramel stability is achieved by inverting the sucrose to dextrose and levulose, followed by the addition of a strong alkali, normally ammonia, to raise the pH and provide a source of nitrogen which is an essential component of the colour forming compounds.

During the boiling process the pH drops steadily as the organic acids increase, water molecules are discharged and the colour develops at a uniform rate.

To meet the demands of various industries using caramel in their products, it is essential where colour is required in bright liquids, that the type of caramel used remains "brilliant" and possibly enhances the brilliance and shelf life of the product.

Particular significance in the selection of a caramel is attached to its isoelectric point, which should be similar to that of the product. A simple explanation of this characteristic is provided by that of magnetism in a liquid state; where like charges repel and unlike charges attract one another; so like-electrostatically charged molecules repel, remain in solution and hence remain brilliant, while unlike charged molecules attract, fuse together and form insoluble particles, hence a turbid solution.

The reason for the necessity to produce various types of caramel is to provide for the wide range of isoelectric and other characteristic properties in the final product.

Acknowledgments

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