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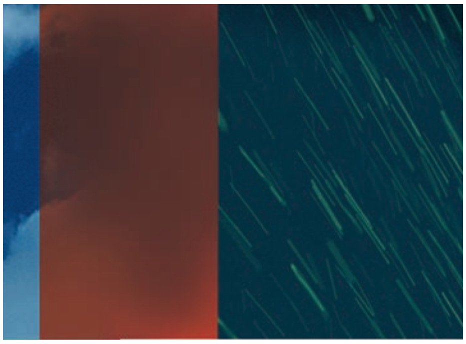

SUGAR QUALITY AND WHAT AFFECTS IT

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Sugar quality is the term applied to raw sugar to describe the chemical composition of the sugar and its fitness for the purchaser's intended use. More often than not, this involves refining to white sugar. The world market for raw sugar is extremely competitive and appropriate sugar quality is often the difference between making a sale or not, and the securing of a favourable price for the sugar sold.

Australian sugar is recognised as a high-quality product and considerable time, effort and capital resources have been expended to achieve this reputation. Even higher standards are important to compete effectively with other exporters of raw sugar.

This chapter outlines important factors in maintaining and improving raw sugar quality from a canegrowing perspective, and why various sugar-quality parameters are important to raw sugar mills and refineries. Returns to growers and millers are affected by sugar quality.

RAW SUGARS

Raw sugar is produced and sold in classes or 'Brands', where each Brand has specified quality standards, which are to be met in the raw sugar produced.

The major raws supplied are Brand JA, Brand 1 and Brand VHP in order of increasing polarisation. Brand 1 is the staple product, Brand JA is produced for the Japanese market, and the higher pol Brand VHP and specialty high-pol sugars are increasing in customer requirement. Brand JA has a pol around 97.8, Brand 1 has a pol around 98.9 and Brand VHP has a pol around 99.3 with decreasing impurity levels accordingly. The relative production of these Brands is varied according to customer requirements. In 1999, Brand JA was approximately 15% of total production, Brand 1 74% and Brand VHP 11% of total production. Higher pol raws are available.

Before the start of each season, Queensland Sugar Limited negotiates with the mills for production of the sugars it requires to meet the anticipated market.

The production of raw sugar is controlled to meet sugar quality standards for constituent analyses such as polarisation, moisture, ash, colour, filterability, fine grain, starch, dextran, and temperature.

A standard such as temperature is largely influenced by mill operations. Polarisation, moisture and fine grain have a major mill component, but impurities introduced with the cane can play a part in influencing the steps the mill needs to adopt to meet the standard for these characteristics. The remaining parameters are primarily influenced by impurities in the cane, but the processes adopted by the miller can assist in reducing their importance.

Polarisation (pol)

Pol is the measure of percent sucrose in the raw sugar. It is the main selling criterion and the prime figure upon which payment is fixed. The other criteria provide benchmarks for the purchaser to judge the processing characteristics of the sugar and to compare the sugar with that of other suppliers, and thus fix the price against competition. In the extreme, a buyer will refuse sugar if it does not meet the standard for a particular criterion.

The mill influences pol primarily by the quantity of molasses that is left on the surface of the crystals of raw sugar at the centrifugals. Certain impurities, such as those which increase sugar solution viscosity (ash, starch, dextran) or crystal shape modifiers (dextran and trace impurities), which have their origin in cane, adversely complicate a mill's efforts to produce sugar of the desired pol. These impurities interfere with the crystal growth processes and subsequent separation of crystal.

Moisture

Control of moisture in raw sugar is important because of its influence on the handling of the sugar. Sugar that is too wet is difficult to handle and, if seriously wet, the sugar will deteriorate. Sugar that is too dry presents a dust hazard in handling and transfer in the shipping operations. Dust explosions can result.

Moisture is primarily a mill issue, but it can be made more difficult if impurities, which influence crystal growth or molasses viscosity such as dextran, ash or starch, are present beyond normal levels.

Ash

Ash is inorganic material in cane juice and a small, but significant, carry-over into raw sugars. Ash in the cane supply includes such substances as chlorides, sulfates, phosphates, and silicates of minerals including calcium, potassium, magnesium and aluminium, as well as clay and sand. These originate in the field. The mill process removes phosphates from cane juice into filter mud, but other inorganic salts can continue through processing, largely to molasses and in much smaller amounts to raw sugar.

Ash increases the solubility of sucrose in water and as a consequence, reduces the amount of pure sugar that can be produced from cane in a mill or from raw sugar in a refinery. High ash devalues the incoming cane or raw sugar.

The ash constituents enter the cane from the soil, water or added fertilisers. Different varieties incorporate different quantities of ash constituents. Growers are encouraged to take advice from BSES to select low-ash-level varieties when this is possible. However, the growing environment and extraneous matter levels are usually much more significant than varietal effects.

Ash is high in tops, trash and dirt adhering to cane. For example, cane tops can contain 12 times as much ash as cane stalks on a dry juice basis. High topping can increase ash in juice by 20%. Clearly, ash can be reduced by reducing extraneous matter.

The presence of elevated levels of salt in soil or irrigation water stimulates uptake of a range of mineral salts by the cane plant in its attempt to maintain a favourable osmotic balance with salts in the root zone.

Therefore, ash in juice and sugar increases in response to salts in soil and irrigation water. Salty soils are best avoided for cane production because of effects on yield and ash. Localised areas of soil salinity may respond to improved drainage, if the salting is associated with an elevated watertable. All irrigation waters contain some salt. Therefore, good drainage and leaching with rainfall are essential to avoid build-up of salts in soil. Low-salt irrigation water is always preferred for high productivity and low ash.

Potassium salts are major constituents of ash. Sugarcane can acquire potassium in luxury amounts from soils of high fertility, from excessive rates of potassium fertiliser, or from soils amended with high rates of ash from sugar mill boilers. Juice ash levels can be increased by 50% in cane where excess potassium fertiliser and poor quality irrigation water have been used. Thus, there is potential for reducing potassium ash constituents in cane by applying only the potash fertiliser required to balance crop requirement against that already obtained from soil and or boiler ash.

Colour

Cane juice and the resultant sugar contain coloured materials. These colourants are organic and are a complex mix of compounds. Colourants are derived from low molecular weight substances in the cane at harvest. High molecular weight colourants are produced by reactions between the colour pre-cursors and other juice consituents during the milling process.

The high molecular weight substances are considered the more damaging as they are more readily incorporated in the sugar during the pan boiling and crystallisation stages of the process and more severely overload raw sugar refinery processes. High molecular weight compounds are made up of polymers (large molecules) formed by the oxidation of low molecular weight plant pigments called flavonoids and phenolic acids and from mill reaction products. The latter include polymers formed from reducing sugars under alkaline conditions (so called alkaline degradation products), polymers formed by the reaction of reducing sugars and amino nitrogen compounds in the mill and in storage (melanoidins), and colourants formed by the caramelisation of sucrose at elevated temperatures. The amino nitrogen substances and flavonoids are often called colour precursors, because of their subsequent involvement in the formation of additional colourant.

Refiners rate colourants as the most important impurity in raw sugar. The various colourants respond differently to the refining process. High molecular weight colourants create the most difficulty.

A refinery's customer for sucrose typically is seeking a sweetener and does not want colour or associated flavours. Therefore, a low-colour raw sugar is sought by the refiner. It is preferable if the colourant is confined to the syrup film surrounding the sucrose crystals. The removal of colour from sugar solutions is primarily accomplished by adsorption of the colourants onto a suitable medium, such as carbon, char (which is retorted animal bones) or ion exchange materials, and then crystallisation. The decolourisation medium is freed of colourant and then reused. These operations are expensive.

Varieties vary in their propensity to produce colour. Additionally, colour is much higher in the tops, trash and suckers than it is in the stalk of the cane. Tops and trash have 7 and 36 times, respectively, as much colour as the cane stalk. Trash not only adds a loading of colour but also increases the loading per unit weight of impurities which, in practice, has a very strong adverse effect on raw sugar colour.

The prominent and most damaging colourants of cane or raw sugar are formed by the reaction of amino nitrogen and reducing sugars in the mill or in storage. Sugarcane takes nitrogen from soil as nitrate and ammonium ions and stores nitrogen not needed for immediate growth processes as amino acids, primarily in the stalk. Thus, excessive uptake of nitrogen from highly fertile organic soils, or over application of nitrogen fertiliser, will result in high levels of amino nitrogen in cane. High levels can also result from the use of recommended levels of nitrogen fertiliser in situations where drought has prevented use of plant nitrogen in accumulation of expected stalk yield. Asparagine is the dominant amino acid in sugarcane, whereas guanine fulfils a similar position for sugar beet.

Amino nitrogen in the cane supply can now be determined by on-line near infra-red (NIR) spectrometers in sugar mills. With this technology, it will soon be possible to supply canegrowers with amino nitrogen analyses for every rake of cane. The information could be used to optimise use of nitrogen fertilisers for yield, CCS and potential amino nitrogen-based colourants.

Soil in cane also increases colour. Cane, harvested green, when free of extraneous matter, has a lower colour than the burnt equivalent. This is due to the impact of heat on juice close to the epidermis of the stalk.

The factory, too, will generate colour through heat and alkaline reactions and millers must act to minimise this area of colour formation. Maintenance of the effectiveness of the clarification, pan boiling and crystallisation processes is also beneficial to the production of low-colour raw sugar and, particularly, in confining of colourants as much as possible to the molasses film**.**

Filterability

Filterability is defined as the relative rate of flow of a raw sugar solution through a porous bed of diatomaceous earth, compared with the rate of flow of a pure sucrose solution at the same concentration and temperature. The test indicates to some extent the behaviour of a sugar solution if it was carbonatated (carbon dioxide and lime added) and filtered as in a carbonatation-based refinery. A solution of poor filterability reduces the rate of throughput of a refinery. This forces the refiner to adopt lower process sugar concentrations, leading to a loss in thermal efficiency of the refinery, as greater evaporation is required prior to the pan boiling stage than where the process solution contains less water. The end result of low filterability is increased cost for the refiner.

The test primarily responds to the presence of insoluble impurities but also reacts to soluble impurities (particularly high molecular weight substances) such as dextran, gums, soluble phosphate and residual flocculants. Starch is an important impurity in hindering refinery filtration and is not thought to be adequately represented in the filterability test. Therefore, starch is analysed and evaluated separately.

Much of the work to maintain good filterability takes place at the mill's clarification stage, in sugar boiling, crystallisation and sugar centrifugation. The miller needs to control these operations closely, to minimise the carry over of filtration-impeding substances beyond clarification and their incorporation in sugar.

The miller is assisted by receiving good quality, fresh cane, particularly cane that is free of dirt. Dirt overloads the mill clarification process, leads to loss of control, and reduces the effectiveness of clarification. Dirt at the time of wet weather has been frequently reported to have an even greater impact on clarification than under dry conditions due to the presence of unusual trace impurities.

Cane deterioration products, such as dextran, adversely affect clarification, boiling and crystal separation.

Phosphate-deficient soils can lead to cane of low phosphate content. The mill's clarification reaction does not go to completion when low phosphate is present and, strangely enough, leads to retained phosphate in clarified juice and lower filterability sugar. The mill adds phosphate, when necessary, on the basis of clarified juice turbidity. Use of phosphoric acid can be

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costly. It also leads to a situation where dosage is maintained at a level that is excessive for some cane and insufficient for other cane.

Dextran

Dextran is a natural polysaccharide produced by bacteria that infect the sugarcane stalk after damage or cutting. It can also be produced by the same bacteria in the mill and may result from poor mill hygiene.

Dextran increases sugar solution viscosity, adversely affecting clarification. Effects on crystal growth and centrifugal separation processes are more serious. Dextran poisons the fastest growing faces on the sugar crystal, slowing the production of correctly sized crystals and necessitating crushing rate reduction. The crystals so formed are not square in shape, as is normal, but can be severely elongated. These elongated crystals perform badly in the centrifugals in the mill and subsequently in refinery boil out materials, as they tend to restrict the flow of molasses away from the crystals. This, in turn, necessitates longer fugal cycles and increased wash water use, which reduce throughput and sugar yield, respectively.

Increased viscosity and changing crystal growth from dextran in juice and sugar leads to poor mill and refinery throughput, and almost certainly leads to higher sugar content in final molasses. This arises from the need to maintain a balance between throughput and mill chemical efficiency. Some efficiency loss is often accepted to maintain rate.

It is important to remember that dextran results from bacterial action, which uses sucrose as an energy source. Therefore, presence of dextran in cane lowers return to the whole industry through lowering CCS, impacts on milling, and sugar quality.

The adoption of chopper harvesting and production of billets for transport and milling led to a re-evaluation of field and transport practices to counter sugar problems caused by dextran in cane juice in the 1970s.

Bacterial deterioration of cane is enhanced if the cut-to-crush delay is extended beyond the industry-recommended maximum of 16 hours, by hotter and humid weather, and by shorter billets which increase the cuts per stalk and the number of surfaces through which bacteria can enter the cane. The Australian industry standard is 250–300 mm billets. However, some mill areas trade off an improved bin bulk density in rail and road transport with shorter billets against minimising deterioration through short delivery delays and green-cane harvesting.

Another source of increased bacterial action is damaged, squashed, cut ends providing more access for organisms to the interior of the billet. These often arise from poorly maintained harvesting equipment or the desire to shorten billets without sufficiently rebuilding the harvester. Burnt cane deteriorates faster than green cane and cane which has an excessively long burning-to-cutting delay deteriorates faster than freshly burnt cane. Stressed or otherwise damaged cane can have elevated dextran levels, as splits, rodent damage, insect entry points, etc., allow bacterial access to the interior of the stalk.

The responsibility falls to all segments of the industry to maintain conditions to avoid deterioration, loss of pol and the formation of dextran.

Grist/fine grain

Fine grain is the proportion of crystals within a batch of crystals with size smaller than a specified screen size. The screen size reflects the crystal size, which gives problems to the refiner. It is important because of its effect on affination (the first stage of the refining process), in which variable crystal size and fine crystal size interfere with the flow of affination syrup (which removes the outer molasses layer) away from the crystals. Poor separation requires increased washing in the affination fugals, causing excessive crystal dissolution and reprocessing cost and/or excessive retention of impurities from the molasses layer with the crystal. This, in turn, causes increased production cost to deal with these impurities.

This standard is a major issue for the miller and is managed through control of the pan boiling and centrifugal processes.

Impurities associated with deteriorated cane are a major disadvantage in producing the desired size range of sugar crystals. Elongated crystals require additional growth to ensure that the shorter of the length to breadth dimension is sufficiently large for the crystals to be retained on the standard screen and not pass through the screen.

Other indications of lower quality cane supply, such as extraneous matter, also introduce impurities that can increase the difficulty of maintaining pan boiling control and performance. Minimisation of these adverse components in cane supply benefits both the grower (improved CCS), the miller (improved process handling and efficiency), and both parties (higher sugar price).

Starch

Starch is a polysaccharide inherent in the growth of plants. It is a storage form for carbon as a plant reserve energy source and, although bred out to a large degree in commercial canes, is present in sufficient quantity to provide problems should it reach the refinery. Starch is entirely derived from cane and exists as amylose and amylopectin in proportions of about 1 : 4.

These starch molecules interfere with refinery carbonatation. Amylose influences calcium carbonate precipitation, leading to fine crystals and increased filter cake resistance. Amylopectin blinds the pores in the calcium carbonate filter bed. Starch is a large molecule and is prone to inclusion in the growing crystal.

There is a marked varietal effect in starch incorporation in cane. The leaves and tops, the growing centres, contain significantly more starch than the cane stalk. Tops contain three times the starch of the stalk and starch is four times higher at the top of the stalk than at the base.

As is the case for most of the deleterious impurities in sugar, sugar quality will be enhanced by the exclusion of tops and trash from the cane supplied to the mill

THE SELLING PROCESS AND QUALITY

Raw sugar customers firstly inquire about price and what grade of sugar will be supplied. The first inquiry for most customers relates to Brand 1. However, the Japanese market requires Brand JA and some customers routinely seek Brand VHP, the higher purity product. The second round of discussions deals with quality issues and actual pol.

Australian sugar is known to have good quality and customers come to the agents with a first offer of refusal. They know that they are going to get consistently good quality, reliable supply and shipping and that the Australian industry delivers the product it promises. Of course, if the price the customer is offering is unrealistic, the business is not pursued further. Attainment of ‘first offer status’ and recognition of quality in supply and performance will often enable a premium in price to be achieved over other suppliers of raw sugar.

A customer may require a pol guarantee or a guarantee on overall colour and penalties for not meeting the standards on such criteria as pol, colour, dextran, starch and fines. Few countries actually specify affined colour, and total sugar colour is the main focus. Others question closely on ash and colour, but the outcome is not registered in the contract.

The most important criteria at the marketing desk are pol, colour, dextran and starch and then ash, reducing sugar and fine grain ranked together. Filterability does not get raised often; nor is moisture, and this is usually in the context of the effect it has on sugar flow and transfer in storage.

All the attributes are considered in the overall ranking of Australian sugar. A decrease in sugar quality performance in any criterion for a shipment will lead to critical comment and a reassessment of Australian sugar in that market.

Being a first-offer supplier is worth money to both growers and millers and it is worth making sure that the standard of quality continues.

SUMMARY

It is apparent, in all these quality parameters, that best quality cane leads to best quality sugar. In other crops, actions ensure rubbish is not processed with the sound material. Sugarcane requires no less diligence to preserve industry reputation and markets.