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THE COMPARATIVE SWEETNESS AND PRESERVING QUALITY OF CANE AND BEET SUGARS

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AT the present time various grades of white cane and beet sugar are sold on our market, and broadly these may be divided into (1) refined and (2) direct-consumption sugars. By a refined sugar is generally understood a product which is obtained by re-melting raw cane or beet sugar, passing the resulting liquor through animal charcoal to decolorise and purify it, and finally re-crystallising. Granulated and cube sugars so produced in refineries in this country are of a remarkable degree of purity, and their sucrose content generally reaches 99·95 per cent., the traces of moisture, ash, reducing sugars, and organic non-sugars which may be present being hardly capable of determination even by the application of special methods. (Intern. Sugar J., 1920, 654). It is conceded by all that there can be no difference in the sweetness or preserving quality of such a highly refined product (which is in effect pure sucrose), whether it is derived originally from the cane or the beet.

Description of Direct-Consumption Grades

The direct-consumption sugars, as the term suggests, are grades produced directly from the cane or the beet without the intermediary of the refinery, or the use of animal charcoal, of suitable purity for use on the table or for manufacturing purposes. They are made by liming and sulphiting or carbonating the juice, filtering the syrup or allowing it to subside, and washing the resulting crystals with water and steam in the centrifugal machine. The best grades of cane or beet sugar thus made have a sucrose content of about 99·5 per cent., are of good colour, and can very well be used for domestic purposes, though admittedly they do not possess as a rule the faultless appearance of the best refinery product. Excellent direct-consumption cane sugar is now being imported into this country (though as yet in comparatively small amount) from the British West Indies (a recent analysis gave, per cent. :—sucrose, 99·5; reducing sugars, 0·23; ash, 0·02; organic non-sugars, 0·15, and moisture 0·10); whilst as an example of a superior direct-consumption beet sugar may be mentioned the granulated sugar produced at the beet-sugar factories in this country during the last season (*cf.* J., 1922, 149–154 R, Kelham sugar giving the following figures: sucrose, 99·9; reducing sugars, absent; ash, 0·01; organic non-sugars, 0·04; and moisture, 0·05 per cent. Cantley sugar is equally pure). Other grades of direct-consumption sugars are used in the United Kingdom in the jam, confectionery, biscuit, and condensed-milk industries, though these are often "off-colour," and therefore not in demand in the grocery trade.

These lower grade direct-consumption sugars have only a slightly smaller sucrose content than the refined article; and the difference between them and pure sucrose is to be attributed to the small amount of impurities, such as reducing sugars, ash, and organic non-sugar matter (the last-named including traces of colouring and aromatic substances), which are occluded in the interstices between the lamellæ of the crystals. Direct-consumption cane sugars generally contain reducing sugars, and may possess a slightly acid reaction, whilst the trace of non-sugar substances which they contain imparts a faintly pleasant flavour derived from the original juice. On the other hand, beet sugars normally do not contain reducing sugars, and in the case of the lower grades their solutions may be slightly alkaline. Further, the inferior grades of white beet sugars, such as the so-called "washed crystals," may still retain a trace of the objectionable (almost nauseous) flavour that is so characteristic of the juice from which they are extracted. Then in this description of direct-consumption grades mention may be made of the palatable and wholesome West Indian yellow crystal sugars, which are manufactured directly from cane juice by a special process of clarification and boiling; that is, of course, the genuine Demerara or Trinidad crystal sugars, and not the yellow crystals made by some houses in this country by incorporating white crystals (sometimes beet) with a syrup containing a suitable organic dye. They consist approximately of 96 per cent. of crystal surrounded by a syrup containing reducing sugars, ash, and organic non-sugars, including the bodies imparting the very pleasant taste and aroma of the cane juice. The precise nature of these flavouring substances remains undetermined.

Comparative Sweetness of Cane and Beet Sugars

The opinion appears to be quite widely held, and in fact is often definitely expressed, not only by the general public and by sugar salesmen, but also by physiologists who have considered the matter, that the various grades of sugar on the market do actually differ in sweetness, in spite of the fact that their sucrose content may be about the same. Even in Germany there are many who admit that "colonial sugars" (*i.e.*, cane products) are sweeter than the lowest grade granulated beet sugar sold there, or even than the char-refined beet product. It seems, therefore, of some interest to examine the question, and to state the known facts which may account for such an opinion.

Preliminarily, it may be pointed out that a correct judgment can hardly result from tasting the crystals themselves, since their size and hardness considerably influence the sweetening effect thus obtained. It is evident that a fine and soft-grained sugar will pass more quickly into solution in the mouth than a product consisting of hard and large crystals. Obviously, therefore, tasting experiments must be performed with solutions of the various samples, using preferably a saporimeter, such as that designed by Kremer (Nederl. Tijdschrift voor Geneeskunde, 1917, No. 3, 149-157), whilst also following a suitable method for diluting the sapid substance with water, and a definite procedure for eliciting the decision of the individual tasters, such as that described by Toulouse and Vaschide (Comptes rendus, 1900, 130, 803; 1904, 139, 898).

The reader may be reminded that on the surface of the tongue and soft palate are numerous papillæ, of which many bear at the base or on the top the so-called "taste buds," structures which are the terminations of the gustatory nerve fibres. These nerve endings are capable on excitation of giving rise to gustatory sensations, which are broadly classified as sweet, acid, bitter, and salt. Each of these sensations is believed by many physiologists to be registered by a specific set of nerves; in other words, the particular nerve endings producing the sensation of sweetness appear to be incapable of excitation by an acid, a bitter, or a saline substance.

An important fact here to bear in mind is that there appears to be reliable evidence for the statement that the intensity of a gustatory sensation (sweetness, for example) may be modified when another set of nerves in the vicinity (say, those producing an acid taste) is at the same time excited (Zeitsch. f. Psychologie u. Physiologie der Sinnesorgane, 1899, Bd. 21).

Influence of Traces of Acid and Alkali on Sweetness

Thus, it will be found that if two solutions be prepared, the first containing 15 and the second 12 per cent. of sucrose, and if to the latter a trace of acid be added, it is possible by gradually increasing this addition to arrive at a certain concentration of the mineral or vegetable acid at which most of the tasters would consider the weaker solution of sucrose to be the sweeter (Archives Néer. Physiol., 1917, 1, 625). A similar result has been obtained by adding quinine hydrochloride and other bitter substances (Du Bois Raymond's Archiv f. Physiologie, 1892). It has been established that if two solutions be made up both containing, say, 15 per cent. of sucrose, and if to one of them about 0·1 per cent. of sodium chloride be added, nine persons out of ten tasting the two liquids would declare the solution containing the small amount of salt to be appreciably the sweeter (Archives Néer. Physiol., 1917, 1, 625). It is, of course, well understood that if the amount of any one of these additions is increased beyond a certain point, the acid, the bitter, or the saline taste will become apparent, and the solution of sucrose will then certainly become less sweet. On the other hand, it has been proved that traces of alkali depress the sweetening effect of a solution of sugar, and a well-known German chemist once stated (Vereinszeitschrift, 1892, 42, 580): "According to my experience, the sweetness of sugar is greater when traces of acids, especially fruit acids, are present than in solutions which, as in the case of our beet sugars, contain a trace of alkali."

Influence of Odoriferous and other Foreign Substances

Further, the sense of taste is certainly affected by odoriferous substances. In an authoritative textbook ("A Textbook of Physiology." By Sir Michael Foster, in Part IV. The Senses. Page 1513) the statement is made that if the nose be held, and the eyes shut, it is very difficult in eating to distinguish between an apple, an onion, and a potato, the three being recognised when their respective aromas are eliminated only by their texture in the mouth, and not by their "taste." W. H. Th. Harloff remarked (Intern. Sugar J., 1920, 105) that when palm sugar (which is exceedingly luscious) is dissolved in water and treated with a decolorising carbon for the absorption of its non-sugars, one obtains a liquid that is much less sweet than the original solution, although its content in sucrose and reducing sugars may be the same. A similar observation was made by F. I. Scard (ibid., 1904, 478) to the effect that the pure sucrose obtained by washing Demerara sugar to remove the adhering syrup, and recrystallising the white sugar left appeared almost tasteless in comparison with the original crystals.

These several points regarding the factors capable of influencing the sweetness of a sugar seem to be well established; and in fact are so well recognised that the proposal has been made to add traces of vegetable acids and flavouring

substances to pure white sugar for the purpose of increasing its sweetness and palatability as a commercial article.

Summarising the conclusions to be drawn from the observations cited above, it may be said that there appears to be good evidence for the opinion that some grades of white sugars, namely, those containing traces of acid and flavouring substances, may be sweeter than others, when tasted in solution. Thus, by way of example, if one were to examine in the manner already indicated four different grades of sugars, viz., (1) the best refined; (2) a low grade cane direct consumption; (3) Demerara yellow crystals; and (4) an inferior beet direct consumption, there seems little doubt that in the opinion of the tasters the Demerara yellow crystals would be considered somewhat sweeter, weight for weight, than the refined article, in spite of there being a difference of about 4 per cent. in the sucrose content of the two sugars. Further, it seems certain that the direct-consumption cane sugar would be adjudged slightly sweeter than the refined, though less sweet than the Demerara product; whilst the least sweet of the four would probably be the inferior beet, especially if this were of the washed crystal type containing a small amount of alkali carbonates, such as was imported into this country from Germany and Austria previous to the war.

Preserving Quality of Cane and Beet Sugars

The preserving quality of a sugar, whether derived from the cane or from the beet, depends upon several factors, two of the principal of which are: (1) its freedom from micro-organisms capable of inducing fermentation; and (2) its reaction, which should be neutral, or slightly acid. It should also be free from any flavouring or colouring matter which may adversely affect the taste or appearance of the preserve.

In regard to the first factor, namely, freedom from septic micro-organisms, it was formerly claimed that refined sugars only should be used for preserve-making on the ground that it was only by the use of animal charcoal that a sterile product could be obtained. However, direct-consumption sugars made from both cane and beet are in use at the present time in the jam, fruit-canning, and condensed-milk industries with results as satisfactory as those obtained with the refined grades.

It is now known that in the manufacture of direct-consumption sugar, whether by sulphitation in the cane-sugar house, or by carbonatation in the beet factory, a practically sterile juice results after allowing the precipitate of calcium sulphite or carbonate to subside or filtering off. (Intern. Sugar J., 1919, 465). Subsequently, both in refining and in manufacturing direct-consumption sugar, some re-infection occurs when the crystals are exposed to the air in the centrifugals, due no doubt to the large volume of air which is sucked against the mass during its very rapid revolution; but later if the sugar be treated with steam while still in the machines practically all the bacteria and moulds are destroyed (Intern. Sugar J., 1920, 591). The importance of the sterilisation of sugars in this way, and of their packing, storage, and transit under cleanly conditions, is now recognised by manufacturers of high-grade direct-consumption sugars.

Coming to the second factor mentioned above, namely the reaction of the sugar, it is of course well recognised that in jam and jelly manufacture the fruit juice must have a certain acidity, otherwise the pectin will not jell. Investigation of the reason why in preserve-making a syrup instead of a jelly may result has sometimes indicated, when a low-grade beet sugar has been employed, the presence of alkali carbonates in sufficient amount to lower the acidity of the fruit juice below the optimum for the setting of the pectin. However, this condition is hardly likely to be encountered at the present time, though it may well serve as some explanation of the origin of the popular prejudice which persists against the use of beet sugar for the purpose. Most of the white grades of cane and beet sugars now on our market are of high purity; and the British beet sugars have been shown to give entirely satisfactory results in the jam, condensed-fruit and other industries in which sugar may be used In jam and jelly manufacture it would seem that in the event of trouble the sugar used is usually the factor for suspicion; whereas the actual reason for the refusal of the fruit juice to jell is more likely to be connected with other causes, such, for example, as the low acidity of the fruit juice, an insufficient pectin content, the hydrolysis of the pectin by prolonged boiling, or the use of too high a proportion of syrup.

Cane Sugar v. Beet Sugar

The death-blow to the notion that for some peculiar reason or other sugar which is derived from the beet is unsuitable for use in the preparation of jam or jelly and fruit preserving was given by G. W. Shaw, of the Experiment Station of the University of California, in a series of comparative tests (Intern. Sugar J., 1919, 619). The cane sugar was a product originating from the Western Sugar Refinery, San Francisco, and had a sucrose content of 99·7; whereas the beet sugar was a white granulated product made directly from the root by the American Beet Sugar Co., of Oxnard, Cal., and polarised 99·8 per cent. A large number of fruit-preserving tests (about 2000) showed that the two sugars gave identical results, and that in both series the product was as clear as it was possible to be. Not the slightest difficulty was experienced in the preservation in either case.