It hardly seems to need stating, but the world in general, and the United States in particular, is experiencing an epidemic of obesity and overweight. The prevalence of these unhealthy conditions is dramatically higher in the United States now than a few decades ago. The latest Dietary Guidelines for Americans (9) notes that obesity has doubled and in some cases tripled since the 1970s. A third of the U.S. population is overweight and another third is obese (2). All ages are affected, and a particular concern is the appearance in children of weight-associated diseases and conditions that were once diagnosed primarily in adults.

So far, so familiar, but what may be less well-known is that baked goods are the leading source of calories for all Americans 2 years of age or older (6). “Grain-based desserts” provide more energy than any other category—an average of 138 kcal per person per day. Yeast breads are number two in the list. The much-criticized sodas are relative laggards, appearing at number four in the list. It is true that sodas are by far the most significant source of added sugar, but grain-based desserts are the second most important, accounting for 13% of all added sugar in the U.S. diet (7).

It is facts like these that have caused many concerned consumers to be especially wary of added sugar in all its forms. The latest survey of consumer attitudes by the International Food Information Council (4) shows that more than half of all consumers who consult the nutrition facts panel look at sugar content. Even more (60%) check for sugar in the ingredients list, and regardless of whether they use label information, 56% of Americans claim to be trying to limit their intake of sugar.

Thus, there is considerable public concern about the sugar content of foods, much of it focused on seeking ways to reduce added sugar in the diet. At the same time there is a growing interest by consumers in natural ingredients, accompanied by a trend toward products with “clean labels” that minimize the number of synthetic additives. As a result, a significant portion of those concerned with sugar intake is also disinclined to accept existing, synthetic low-calorie sweeteners, despite their advantages. Until recently, a potentially large segment of the market for high-value, reduced- and no-added-sugar products remained substantially undeveloped for lack of available natural zero-calorie sweeteners. Although erythritol has been available as a natural bulk sweetener, it has a potency of only about 0.6 (sucrose = 1) and can require an added high-potency sweetener to boost sweetness back to the level of the sugar being replaced. The appearance in late 2008 of rebiana as a GRAS (Generally Recognized as Safe) ingredient for use in a wide range of foods and beverages transformed the market by making available a plant-derived, high-potency sweetener that could be used on its own but that also complements erythritol or even sugar itself.

**What Is Rebiana?**

Rebiana is the common name for high-purity rebaudioside A (reb A). This zero-calorie molecule originates in the leaves of the stevia plant, *Stevia rebaudiana*.*

![Stevia rebaudiana](image)
Bertoni (Fig. 1), where it occurs along with eight other closely related compounds collectively known as steviol glycosides. The best known and most abundant of these glycosides is stevioside, but the less-prevalent reb A is widely held to be the better-tasting glycoside of the group (8). For this reason, conventional plant breeding techniques have been deployed successfully for many years in an effort to increase the yield of reb A. Today, the total steviol glycosides content in stevia leaves can run as high as 15% of the dry matter, and reb A can comprise ≈40% of the total.

These glycosides are readily extracted from dried leaves using water and, when dried, provide a powder containing a very high concentration of steviol glycosides, albeit in variable proportions and mixed with other water-extractable plant components. This stevia extract is itself an article of commerce but is only the starting point for rebiana production. The extract is redissolved and then carefully recrystallized under controlled conditions to isolate rebiana. The recrystallized product consists of a minimum of 95% reb A, with other steviol glycosides making up the balance. The specification for rebiana can be found in the Food Chemical Codex (10).

Rebiana is a high-potency sweetener. That is to say, it is many times more effective than sugar on a weight basis. As Figure 2 shows, its potency depends on concentration, but it is 250 times as sweet as sucrose when tasted at the sucrose equivalent of a 5% sugar solution. The concentration dependence of rebiana’s sweetness is shown in Figure 3.

Although rebiana is a stevia-based sweetener, not all stevia-based sweeteners are rebiana. Since the introduction of rebiana in the United States numerous other steviol glycoside preparations have acquired GRAS status. Many of these have lower reb A contents and correspondingly higher amounts of stevioside. Although this can lead to lower prices per kilogram of powder, there may be disadvantages due to differences in taste quality and sweetness potency. The sweetness potency of reb A is approximately twice that of stevioside.

Natural Bulking Agents

Rebiana offers the ability to use a plant-derived molecule to sweeten products without adding calories. The key success features of reduced-sugar products are excellent taste and appearance, and baked goods are no exception. Bakery products, however, pose a more severe formulation challenge because the physicochemical properties of sugars are as important to the structure and appearance of baked goods as flavor. Simply stripping out the sugars and replacing their sweetness with a high-potency sweetener does not work, and other additions are needed to replace the other functions of the sugars. In practice, a range of bulking agents is available for this purpose; however, only some may be labeled as natural, e.g., erythritol, inulin, and maltodextrin. Erythritol is particularly advantageous because it also has a zero-calorie content. Rebiana is ideal for boosting the sweetness of erythritol, because while its sweetness simply adds to that of erythritol the two are also qualitatively synergistic. Each improves the sugar-like taste of the other so the combination is better tasting than either alone.

The combined use of rebiana with erythritol and/or inulin is a practical means of reducing the sugar content of baked goods while retaining the attraction of natural ingredients (3). For example, both reduced-sugar cookies and muffins can be made that have an appearance nearly identical to their full-sugar counterparts and that earn equal sensory scores. Figure 4 compares the two types of muffins straight from the
oven; Table I presents key product statistics; and Figures 5 and 6 show the sensory scores for the products.

The hedonic ratings (Fig. 5) for the cookies show a directional preference for the flavor of the full-sugar version, i.e., the scores are not sufficiently different to indicate full statistical significance but do suggest the direction in which the panel tended. On the other hand, there is a directional preference shown for the texture of the reduced-sugar cookies. The scores for the muffins (Fig. 6) are not significantly or directionally different.

**Stability of Rebiana in Baking**

It might reasonably be inferred from results such as those for the cookies and muffins that rebiana is stable in baked goods. Nevertheless, it is important to verify that this is so, especially since the European Food Safety Authority (EFSA) has suggested otherwise (1). Table II presents the results of analysis of the reduced-sugar cookies and muffins, as well as a reduced-sugar banana bread and white cake. The results demonstrate that virtually all of the rebiana remains intact and is recoverable after baking.

Based on these results it is evident that rebiana is stable during the baking processes applied to flour-based confectionery. However, rebiana’s use is not limited to the batter or dough of cakes and pastries. Rebiana can be used equally well to sweeten creams and frostings, and it complement the inherent sweetness of fruits used in fillings, jams, toppings, and sauces without adding calories. As in cakes and pastries, rebiana’s stability in these applications depends on the key factors of pH, temperature, and time. The glycoside is less stable at the low pH levels encountered in fruit preparations than at the near-neutral levels that are generally encountered in batters, doughs, creams, and frostings.

The behavior of rebiana at low pH is illustrated in Figure 7, which also reveals the wide range of its stability—over five orders of magnitude between 0 and 100°C. Not surprisingly, rebiana was least stable when subjected to low pH at high temperatures for prolonged periods. That said, the glycoside was able to withstand routine food processing, including canning.

Figure 7 has been deliberately calculated for a 25% loss of rebiana based on a rule of thumb used in the beverage industry for dealing with unstable sweeteners like aspartame. In soft drinks, a 25% loss is regarded as the limit of what is tolerable in terms of taste and dictates the sweetness shelf life. The breakdown of rebiana is different, however. It goes without saying that the decomposition products have been tested and are safe, but what might be less obvious is that they are high-potency sweeteners in their own right, i.e., rebiana

![Graph showing stability of rebiana at low pH and dependence of time to 25% analytical loss on temperature.](image)
breaks down and produces other sweeteners. As a result, the actual loss in sweetness is significantly less than the analytical figures would suggest. In fact, a 25% loss of rebiana equates to about a 12% loss in sweetness, a change that many consumers would have difficulty identifying (11). Thus, the results illustrated in Figure 7 indicate there is a substantial margin of safety regarding rebiana’s real shelf life.

Conclusions

More than half of all Americans are trying to reduce their sugar intake, and similar numbers are scrutinizing food labels for information on sugar content. At the same time, many are resistant to the use of synthetic additives, regardless of their safety, and instead are seeking natural ingredients. Rebiana, high-purity rebaudioside A, is a good-tasting, zero-calorie, high-potency sweetener obtained from the dried leaves of the stevia plant by aqueous extraction and subsequent recrystallization. Rebiana can be used as a stand-alone zero-calorie sugar substitute or together with natural bulking agents such as erythritol and inulin to provide an alternative to both the functionality and taste of sugars in baked goods. This approach can reduce or eliminate the impact of sugars listed on the product label, while meeting consumer needs for a nonsynthetic sweetening system.

Rebiana is stable in baking processes, and very high recoveries are obtained with flour-based systems. Although somewhat less stable at the low pH of fruit fillings and similar products, rebiana is still capable of withstanding typical process conditions. In addition to fruit preparations, it is suitable for sweetening dairy-based fillings, frostings, and toppings and can significantly reduce the amount of sugar derived from these, to the benefit of label declarations.

References

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