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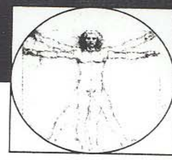

BIOTECHNOLOGY

Is Fabulous Food The Next Fountain Of Youth?

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ALL U.S. GOVERNMENT (F.D.A.)-APproved "low-calorie" sweeteners on the market today are several hundred times as sweet as table sugar. Though caloric, such small quantities of these chemicals are needed to produce sweetness that they add essentially no calories to the final food product. Where food products do not depend on the bulk properties of sugar, these "high-intensity" sweeteners fill a very large need, primarily in the product areas in which the bulk is supplied by water, such as beverages, or where tiny pills, powders or drops serve as tabletop sweeteners.

But products requiring the bulk of sugar, like baked goods, ice cream, frozen desserts, candies and gums have a problem. So to address that market, food product manufacturers have attempted to use a high-intensity sweetener together with a "bulking agent." Unless the bulking agent is non-caloric, however, it puts back the calories the sweetener replaces. Only one synthetic bulking agent has been approved for use in the U.S., and it is somewhere between 25 and 50 percent caloric, as compared to table sugar. Moreover, there are taste problems with a number of products formulated with it.

In general, then, today's consumer remains unsatisfied in his quest for low-calorie, staple foodstuffs.

There is now hope, though, that this important product void can be filled. We at Biospherics are developing two promising candidate sweeteners.

It all began with the insatiable curiosity of Louis Pasteur, who puzzled over his observation that when chemically synthesized sodium ammonium tartrate in solution was dried into crystals, equal quantities of two distinctive shapes appeared. And no matter how he rotated the crystals, the two different forms did not match up. They were mirror images. Pasteur concluded that this difference between the two crystal forms was caused by a geometric difference in the arrangement of the atoms in the constituent molecules. Other scientists identified the difference at the molecular level. They named the chemically identical forms "left-handed" and "right-handed." The "left-handed" molecule remained untouched in the solution and, when dried, formed left-handed crystals only. This was the first evidence that left-handed and right-handed versions of the same chemical compound behave differently biologically and is the basis for our use of left-handed sugar (and, increasingly, for new pharmaceuticals).

It is now believed that living forms evolved through the ages using and making energy-rich sugars of the right-handed version only. Conversely, and equally inexplicably, the first living system selected only left-handed amino acids out of which to build the tissues of life. Being descendants of that first living progenitor, the enzymes responsible for making energy available to us respond only to right-handed sugars.

I was mindful of this fact when I was designing an experiment to look for life on Mars. The strategy was to see if Martian soil contains microorganisms by adding food and seeing if it was used. I thought it a good idea to include both left- and right-handed molecules in that food, since no one could predict which type any Mars life might prefer. Imagine the *Viking* mission experiment successfully arriving on Mars but failing because it offered the wrong food!

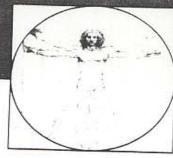
The uncommon left-handed L-sugar had to be carefully synthesized. In the course of incorporating it into the Mars-bound nutrient, I tasted it. I was surprised to find it sweet, because theory predicted that the taste process, governed by right-handed enzymes, would not recognize the L-sugar. In fact, a hastily convened taste panel confirmed that the L-sugar is just as sweet as its right-handed twin!

Biological processes in yeast also operate in man. If L-sugar is sweet and cannot be metabolized, might it not provide a much-needed, non-caloric bulk sweetener? If the idea were proven true, there would be but two obstacles: the price of L-sugar at that point was about $30,000 a pound–making a low-calorie cake a little costly; and the substance had to be proven nontoxic to humans. All the other problems faced by the high-intensity sweeteners–lack of bulk, texture, density, browning and difficult formulation of food products–were not problems for L-sugar.

The L-sugar selected for our development was not common table sugar (sucrose) but rather the L-form of one of table sugar's single hexose components. It is cheaper and easier to make than L-sucrose, and it fit better into our market strategy.

Named Lev-O-Cal™, the sugar has shown considerable promise. Research performed to date has produced highly encouraging results concerning its efficacy and safety. Moreover, in the course of that work a serendipitous discovery has enabled us to patent what may prove to be a superior or alternate product for use as a low-calorie bulk sweetener. Unable to synthesize L-tagatose in time for a set of physical tests of the L-sugars, we substituted the naturally occurring D-tagatose since its behavior for test purposes would duplicate that of L-tagatose. Dr. Lee Zehner, director of BioTech Programs, tasted the D-tagatose and found it to be virtually indistinguishable from sucrose.

Although not a left-handed sugar, D-tagatose had not been studied extensively because no practical use had been seen for it. But its taste and physical properties, and the fact that it could be made much more cheaply than L-tagatose, spurred Dr. Zehner to investigate its caloric availability to mammals. A series of tests concluded that D-tagatose does not cause weight gain. A new patent now grants us the exclusive right to use D-tagatose as a sweetener and/or bulking agent and we are now carrying on parallel development of Lev-O-Cal and D-tagatose.



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...wonderful-tasting foods and desserts without the calories...fanciful dream?

Moreover, after a major European company participated in the development of Lev-O-Cal, we licensed the company to use the technology. We will receive royalties on any sales resulting from that license, but we retain the right to develop and sell Lev-O-Cal independently.

Also, Biospherics still owns all rights to the D-tagatose technology. And though we are continuing to develop this product, given the high research costs involved and the several years of remaining development effort, we might share the rights with an investor.

L-sugars and D-tagatose have much in common. Neither contributes to weight gain. Both have clean, sweet tastes, sugar-like texture and mouthfeel, and neither produces an aftertaste. Both brown upon baking. Both are bulk sweeteners. Neither induces an insulin response. Both are simple carbohydrates, chemically true sugars experts think will prove nontoxic. (Health studies performed to date on both non-caloric sugars have shown no toxic effects.) In preliminary tests, both sugars have indicated they do not contribute to tooth decay. And both are slowly biodegraded in the environment.

But it is the differences between the two sugars that give rise to the two strategies. D-tagatose is sweeter than Lev-O-Cal. Its onset of sweetness and its taste profile closely mimic table sugar, as do many of its important physical characteristics. So D-tagatose offers the prospect of being a ready substitute for table sugar that requires little or no alteration in food product formulations. Lev-O-Cal, on the other hand, will chiefly address the bulking agent market because it is less sweet. So it is suitable for use in a variety of processed foods, baked goods and candies.

And in addition to filling this considerable niche for low-calorie sugar, Lev-O-Cal offers the prospect of new types of low-calorie food products. Thus, a whole array of "designer" food products, ranging from low sweetness to that of sucrose and beyond, could be produced.

Both Lev-O-Cal and D-tagatose are uncommon sugars. Traces of L-sugars have been found in some exotic plants, seeds and lower organisms. D-tagatose, on the other hand, is in a number of foods that we eat. This includes dairy and soybean products, honey and human mother's milk. The concentration of D-tagatose in each of these foods, however, is quite small. Nonetheless, the fact that we have all been exposed to D-tagatose provides an encouraging background for the extensive toxicological work to be done. This may protect D-tagatose from the acceptance difficulties experienced by some high-intensity sweeteners of a completely synthetic nature, even though toxicological results were favorable for them.

Further, much progress has been made in developing a cheaper manufacturing process for Lev-O-Cal. Although it is no longer $30,000 a pound, Lev-O-Cal would still require a significant price premium over table sugar. But the high price of diet foods today has not prevented their invasion of supermarkets.

In fact, market studies show an existing and developing demand for low-calorie sweetener/bulking agents that could produce between $1 billion and $2 billion per year in sales by the fifth year after the introduction of either of Biospherics' products. These estimates take into account the probability that the dosage allowance for human consumption of the product will be no greater than that permitted for other low-calorie bulking agents. The studies also suppose that some other, yet unknown bulking agent competes for the market.

Biospherics has produced beautiful and tempting low-calorie sweets that appear indistinguishable from the traditional products we love so much. But while the potential impact of Lev-O-Cal and D-tagatose on the diet food industry is large indeed, were nonfattening sugar to be coupled with the new low-calorie "fake fats," a true food revolution could result.

But before we let our aversions to tampering with foods cause us to balk at the prospect, let's review the bidding. Although at times we decry dieting and the use of diet foods as narcissistic and a depraved practice for cosmetic purposes only, the facts show otherwise:

Obesity *is* the cause of a number of severe health problems, and sugar has been established as a causative agent in tooth decay. Many feeding studies with rats have shown that substantial reduction in daily caloric intake leads to extended life and fewer diseases, including cancers and cardiovascular problems.

While it is a long, yet unwarranted leap of faith from these rat experiments to assume that humans would respond the same way, the studies clearly warrant investigation with humans. Were similar effects to be demonstrated for humans, we could then seek to extend our healthy life span by reducing food intake or eating low-calorie foods.

The few Spartans among us may opt for the former approach, but the majority will surely want to approach the fountain of youth through continued indulgence in wonderful-tasting foods and desserts–but without the calories. A fanciful dream? Perhaps. But even if the truth lies somewhere between our present state of diet and health and that of the utopia just projected, it augurs well for an oncoming food revolution. ●

Gilbert V. Levin *holds 50 patents in environmental engineering and health. He was an experimenter on the* Mariner 9 *and* Viking *Mars missions. A Ph.D. engineer from Johns Hopkins, he has also been employed by several state health departments.*