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Biotechnology and Natural Sweeteners

THAUMATIN

ISSUE: The use of biotechnology to produce the intensely sweet thaumatin protein
PLANT: Thaumatin is derived from the fruit of a West African rain forest shrub
COUNTRIES AFFECTED: Product will be marketed as a low-calorie sweetener in Europe, Japan and U.S.
IMPACT: In combination with other newly developed sweeteners, these products offer the potential to erode traditional sugar markets
WHEN: A genetically-engineered thaumatin sweetener is now being produced in the laboratory; one company will apply for U.S. regulatory approval in 1988-89
COMPANIES INVOLVED: Unilever (The Netherlands); INGENE for Beatrice Foods (USA); (unconfirmed: DNA Plant Technology, Inc. for Monsanto, USA)

Biotechnology is now being used to develop new, natural sweeteners from plants. One of the most promising natural sweeteners, the protein thaumatin, is extracted from the fruit of a West African plant, Thaumatococcus daniellii. Thaumatin is generally recognized as the sweetest substance known to man--about 100,000 times sweeter than sugar. The thaumatin plant originates throughout central and southwestern Africa where its fruits have been used for centuries as a sweetener.

The traditional method of extracting the intensely sweet protein from the thaumatin plant is labor intensive and extremely expensive. Tate & Lyle, a major producer of refined sugar based in Britain, markets a naturally-extracted thaumatin sweetener under the trade name "Talin." Since the thaumatin plant will not bear fruit outside of its natural habitat, Tate & Lyle's thaumatin comes from plants grown in

the Ivory Coast and Ghana. The ripe fruit is frozen and then transported to the United Kingdom where the company extracts and purifies the thaumatin protein.² The end product, Talin, reportedly sells for upwards of \$1000 per lb.³

Talin is currently sold as a low-calorie sweetener in Japan, the United Kingdom, Austria and Switzerland, and is under consideration for approval in various other countries. In the U.S., where regulatory approval for new sweeteners is especially lengthy, Talin has only been approved for use in chewing gum.

Biotechnology and Thaumatin

Several major corporations and small biotechnology firms in the United States and Europe are now attempting to use recombinant DNA technology (genetic engineering) to produce thaumatin protein in the laboratory. In 1985-86, the intensely-sweet thaumatin protein was successfully cloned by scientists at Unilever (the Netherlands) and Ingene (Santa Monica, California, USA).⁵ According to Bioprocessing Technology, "if researchers can increase the yields to economical levels, production in microorganisms will give thaumatin a competitive edge over other natural sweeteners."⁶

Genetically-engineered thaumatin products will be marketed primarily as a low-calorie sweetener. Because of the extreme sweetness of the protein, it can be used in miniscule amounts with virtually no caloric content. Since the product has a licorice-like aftertaste, its application⁷ as a sweetener may be limited to certain products and uses.

The following companies are actively pursuing research to develop a thaumatin sweetener via biotechnology:

INGENE (International Genetic Engineering, Inc.) of Santa Monica, California (USA), has been working on the development of a genetically-engineered thaumatin protein since 1982 under contract to Beatrice Foods (Chicago, Illinois, USA). INGENE holds a patent on the regulatory genetic sequences it developed to produce the thaumatin protein. The company plans to apply for U.S. regulatory approval of a thaumatin sweetener as early as 1988-89.⁸

UNILEVER, a multinational giant based in the Netherlands and Britain, was the first company to express genes for the protein thaumatin in microbial hosts.

DNA Plant Technology Corporation of Cinnaminson, New Jersey (USA) recently announced a new research agreement with Monsanto Corporation (St. Louis, Missouri, USA) "to develop

plant varieties that will act as sources of naturally occurring sweeteners" using cell culture technology. The company refuses to discuss details of the research agreement, and will neither confirm nor deny specific interest in thaumatin.

For more information on these companies, see box, "Corporate Profiles."

New Sweeteners Displace Sugar Market

Biotechnology offers the potential to displace sugar as an industrial sweetener on a massive scale. The substitution of other sweeteners is already underway. In recent years, the introduction of high fructose corn syrup (HFCS--a sweetener manufactured from corn using immobilized enzymes) has seriously eroded traditional sugar markets.

U.S. consumption of HFCS grew from 1.35 million tons in 1978 to 4.3 million tons in 1984, while U.S. sugar imports dropped from 6.1 million tons in 1977 to 1.5 million tons in 1985-86.

The use of sugar substitutes has had a devastating impact on sugar producing countries in the Third World. Caribbean sugar exports to the U.S., for example, dropped from \$686 million in 1981 to about \$250 million in 1985. In the Philippines, sugar export revenues plunged by 39% from 1980 to 1984. According to Dutch researchers, the livelihood of an estimated 8 to 10 million people in the Third World is threatened by the loss of traditional sugar markets and the drop in world sugar prices.

Conclusion

If the thaumatin protein can be economically produced using recombinant DNA technology, thaumatin could capture a substantial share of the sweetener market, particularly for low-calorie sweeteners in the U.S., Europe and Japan. (In the U.S. alone, the sweetener market is now worth \$8 billion, of which \$900 million is low-calorie sweeteners.)

If commercially successful, the thaumatin sweetener will not single-handedly displace traditional markets for sugar. However, thaumatin is only one of several plants which produce naturally-occurring, sweet-tasting compounds. These plants and other sweetener sources will undoubtedly be the focus of further biotechnology research. The development of a thaumatin product via biotechnology is just the beginning of a transition to alternative sweeteners. New products of

biotechnology will lead to the massive displacement of Third World sugar markets in the coming years.

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Biotechnology research is also underway on the following, lesser-known plants which are sources of natural sweeteners:

Stevia rebaudiana - A plant cultivated in Japan, Paraguay and other Asian countries which contains substances up to 300 times sweeter than sugar. Japanese and U.S.-based companies are seeking to produce a stevia sweetener.

Lippia dulcis - A natural sweetener (hernandulcin) derived from this plant is approximately 1000 times sweeter than sugar.

(For more information on these and other new sweeteners, refer to "Natural Sweeteners Find Specialized Niches in Low-Calorie Sweetener Market" in Bioprocessing Technology, August, 1986 and "Demand for Low-Cal Foods Invites New Sweetener Options" in Prepared Foods, August, 1986.)

SOURCES

- ¹Proceedings of the National Academy of Sciences, USA
- ²Vol. 82, p. 1406, March, 1985
- ³"Talin: The Natural Flavour Enhancer", brochure describing Talin distributed by Tate & Lyle Industries
- ⁴Personal communication with representative of Tate & Lyle--company would not disclose an exact price for the Talin product.
- ⁵Personal communication with U.S. representative of Tate & Lyle
- ⁶Bioprocessing Technology, July, 1986, p. 2.
- ⁷Ibid.
- ⁸Bioprocessing Technology, August, 1986, p. 3 and "Talin: The Natural Flavour Enhancer", brochure describing Talin distributed by Tate & Lyle Industries
- ⁹Personal communication with Mr. John Crawford, Vice-President--Finance, INGENE
- ¹⁰Agricultural Genetics Report, November-December, 1986.
- ¹¹Personal communication with DNA Plant Technology.
- ¹²"Is Biotechnology a Blessing for the Less Developed Nations?", by Martin Kenney in Monthly Review, April, 1983, p.13.
- ¹³"Product Substitution Through Biotechnology: Impact on the Third World" in Trends in Biotechnology, April, 1986, p.88.
- ¹⁴Ibid., p. 89.
- ¹⁵Bioprocessing Technology, July, 1986, p. 2.

CORPORATE PROFILES

BEATRICE FOODS, Chicago, Illinois, USA, is a major food and consumer product corporation, with 1985 annual sales of (US) \$12.6 billion. The company ranks # 26 on the Fortune 500.

DNA PLANT TECHNOLOGY CORPORATION, Cinnaminson, New Jersey, USA, is a small biotechnology firm founded in 1981. The publicly-held company specializes in cell culture technology and has numerous research contracts with major corporations working on products such as oil palm, tomatoes, coffee, cocoa, fragrances and flavors.

INGENE, Santa Monica, California, USA, is a small biotechnology firm formed in 1981 which focuses on genetic engineering to develop pharmaceutical, specialty chemical and food products. Research on thaumatin is the company's largest effort in the area of food additives. INGENE became publicly held in mid-1986.

MONSANTO, St. Louis, Missouri, USA, is a major agrichemical corporation with 1985 annual sales of (US) \$6.7 billion, ranking # 53 on the Fortune 500. Approximately one-third of the company's 1985 research budget of \$400 million was designated for biotechnology projects.

TATE & LYLE, Reading, England, is a major producer of refined sugar. With 1985 annual sales of \$2 billion, the company ranks # 247 on Fortune's list of the International 500. The company is not working on a genetically-engineered thaumatin product, but is conducting research on enzymes to produce alternative sweeteners.

UNILEVER, headquartered in Rotterdam, the Netherlands and London, England, is one of the world's largest producers of consumer goods. The company ranks # 18 on Fortune's list of the world's largest industrial corporations, with 1985 annual sales of (US) \$21 billion.

