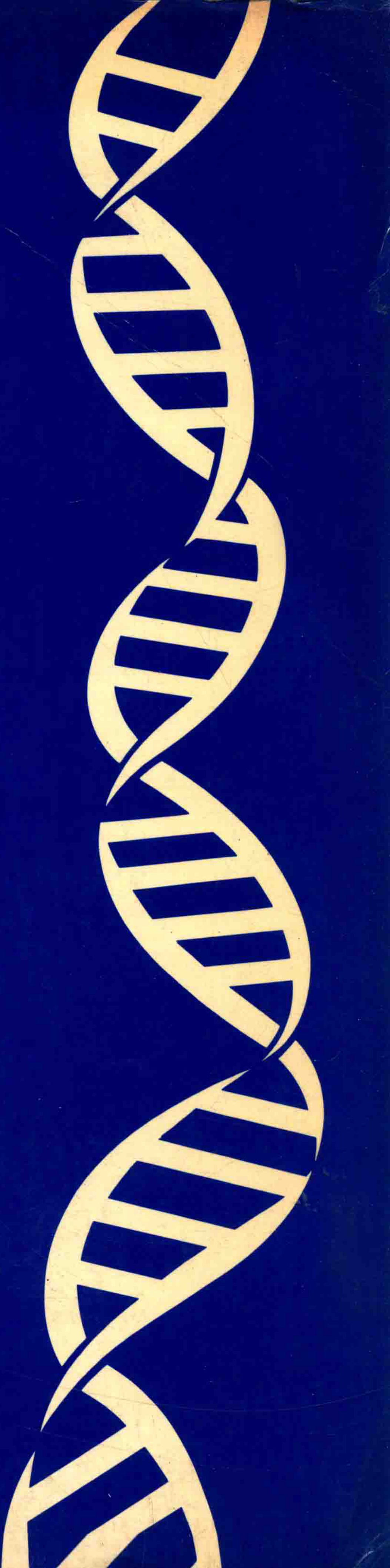
The World Biotech Report 1986

Volume 2: Part 1

FOOD PROCESSING



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Proceedings of the conference held in San Francisco, November 1986

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Introduction

Few new technologies have evoked such a strong and diverse reaction as biotechnology. And fewer still carry with them the burden of so much promise. Since biotechnology emerged as a commercial prospect in the early eighties there has been intense debate among those who see the benefits and those who see the risks of this leading edge technology - one which brings research and commercial application into closer contact than ever before. Yet there can be little doubt that the practical effects of biotechnology are being felt across a widening spectrum of disciplines.

This book focuses on the study of food and food processing and the application of biotechnology to this field. It contains transcripts of the presentations given during the Food Processing Seminar at Biotech San Francisco.

Biotech San Francisco is organized and controlled by Online International Inc. The conference and exhibition continue the highly successful series of events which started with Biotech '83 in London.

Online is one of the world's leading specialists in the design, coordination and management of conferences and exhibitions concerned with the business implications and applications of leading-edge technology. With a schedule spanning some 20 technology areas, many Online events have achieved world forum status. The company was formed in 1971 and now employs more than 100 specialists based in London and New York.

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Biotechnological processes in food production and processing

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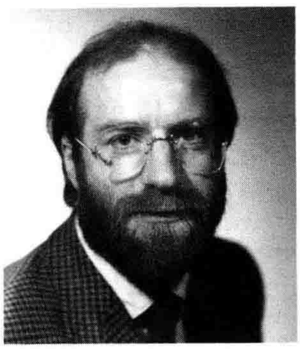
The food industry is the oldest and largest user of biotechnological products and processes. This is shown by examples of the role of biotechnology in food production, including raw material production, modification, improvement and preservation as well as the production of food additives and production/processing aids. Also, the role of biotechnology in food processing is discussed. Here it provides tools and methods for product modification and preservation, unit operations, product characterization, quality and safety and finally, for waste treatment and utilization.



Dr. Knorr is Professor of Food Processing and Biotechnology and leads the Biotechnology Group of the above institution. Main areas of research include biomass recovery, biopolymers and cell cultures as related to food production and processing. He recently edited the book "Food Biotechnology" and is editor of a new journal also entitled "Food Biotechnology."

MAGNITUDE OF FOOD BIOTECHNOLOGY

The magnitude of involvement of biotechnology in food production has been addressed manifold (1,2). The recent discussions about Pseudomonas syringae ("ice minus bacteria"), the worldwide attempts to increase pesticide resistance in plants as well as the production of fuel alcohol from plant biomass are just a few examples of the impact biotechnology will have on food production. Also, the increase in imported foods flooding into the U.S. market at prices that American farmers cannot possible match adds another dimension to the potential role of biotechnology in food production (3).

Interestingly, there is much less public debate on the impact of biotechnology on the processing of food. This is even more surprising if one considers that the food industry is the oldest and largest user of biotechnological processes and products thereof. Estimates of the worldwide market value of the biotechnology-based food industry are around 250 billions US $ which almost equals the total annual sales of the US food processing industry. Out of this more than 10 percent account for alcoholic beverages with projected increases from 27×10^9 in 1982 to 40×10^9 in 1990 (4).

Alcoholic beverages are also, besides vinegar, sourdough and cheese production, the most prominent examples of the fact that biotechnology has been practiced for more than 8,000 years. Meanwhile, there are about 2,000 varieties of cheese around the world (5) and members of the Committee on Biotechnology of the German DECHEMA (6) estimated that in 1990 only 20% of the products known in 1982 will be on the shelves of the supermarkets and that many of the new products will be of biotechnological origin.

BIOTECHNOLOGY IN FOOD PRODUCTION

The role of biotechnology in food production can be organized into (a) raw material production, (b) raw material modification and improvement, (c) raw material preservation, and (d) production of food additives or production/processing aids.

Currently emphasis on raw material production is directed towards increasing productivity through improved efficiency of nutrient use and conversion, or through improved stress resistance, and towards identifying new food sources. Much emphasis is on plant foods, because plant products from fewer than 30 plant species provide worldwide more than 90% of the human diet (1). For example, extensive work is underway to fix atmospheric nitrogen, microalgal mass culture production has been explored over the past 30 years, controlled environment agriculture (i.e. aquaculture, hydroponics) is carried out on industrial scales, and the use of cultured plant cells is being considered for food production (4, 7, 8). The improvement of crop species through regulation of endogenous genes, the transfer of DNA from one species to another and the improvement of plant resistance factors and photosynthetic efficiency are also being sought (1).

In addition, animal products provide annually over 56 million tons of edible protein, marine food products are gaining increasing importance and the use of single cell proteins (SCP) has been stressed over and over again. Consequently, many efforts also exist in these areas with emphasis on improvements in the reproductive efficiency of livestock and improvement of animal breeds. SCP for use as protein source in food and animal feeds is produced on a large scale (9) and solid-state fermentations for food production (i.e. mushrooms) are carried out industrially.

Modification and improvement of raw material can be applied to convert raw material, to increase stress resistance and to improve functional and nutritional quality. For example, polymeric carbohydrates may be removed or included in the product (i.e. dietary fiber) or be converted to other products (i.e. sugars). Work on the improvement of functional properties such as color, flavor and texture of raw material and on the increase of essential nutrients in plants (i.e. by reducing undesirable constituents) is being conducted (10).

Raw material preservation by biological processes is essential to the food production and food processing industry. Here the production of silage, the fermentation of coffee and cocoa beans and the oxidation (commonly called "fermentation") of tea as well as the preservation of any food or feed related biomass via bioconversion are typical examples.

The production of food additives and production/processing aids via biotechnological processes results in a vast variety of products including vitamins (i.e. B_2, B_{12}, C, D), fatty acids and other organic acids (i.e. citric acid), flavors (i.e. vanilla), amino acids (i.e. phenylalanine, aspartic acid), enzymes (i.e. amylases, proteases, glucose, isomerases, pectinases, lipases) and polysaccharides (i.e. xanthan gum, chitosan).

Polysaccharides can be commonly derived from algae or botanical sources and are traditionally used in the food industry as stabilizers and thickeners. More recently, they are also utilized for the microencapsulation of flavors, immobilization of enzymes, and whole microbial or plant cells, as well as in food process waste management (11). They are now being produced commercially through microbial processes and recently advances have been made towards control and manipulation of the biosynthesis of microbial polysaccharides thus offering the potential to affect the structure and form of the final polysaccharide product (4).

The now classic example of the impact that biotechnology can have on the production of a food ingredient is the development of the high fructose corn syrup (HFCS) technology. It involves the application of two amylases and glucose isomerase to effect liquidation and subsequent saccharification of cornstarch to yield a mixture of fructose and glucose. HFCS is about as sweet as sucrose syrup of the same solids content and its use has risen from almost nonexistent in 1970 to 16.4% of the US per capita consumption of nutritive sweeteners ten years later (12).

The rapid development of starter cultures which are important in converting raw material into food products or modifying food material as well as exerting preservative actions on the food, is another important example belonging to this group (13, 14).

BIOTECHNOLOGY IN FOOD PROCESSING

Biotechnology in food processing can significantly alter the composition, quality and functionality of food items. It provides tools and methods for (a) product modification, (b) product preservation, (c) unit operations, (d) product characterization, safety and quality control, and (e) waste treatment and utilization.

Applications of product modification include proteins, polysaccharides, fats and oils. The enzymatic modification of olive oil and stearic acid to a fat similar to cocoa butter or the enzymatic modification of limonoin bitterness in citrus products to improve flavor are promising and potential product modification techniques (15). Meat tenderization with proteases is one example of a large scale application of enzymatic hydrolysis to modify food functionality.

Product preservation via classical biotechnological processes reaches from the preservation of food from plant origins (i.e. cabbage, olives, fruits, soya) to that of animal origin (i.e. dairy products, meat products, fish) (16). Even the production of alcoholic beverages from various fruits can be considered as a food preservation process. Currently much emphasis is on the enhancement of the efficiency of microorganisms used in food fermentation industries.

Roughly 150 to 175 unit operations are involved in food processing and are critical for the quality, functionality and safety of foods. For example, pectinases have been used extensively to enhance the processing of liquid fruit and vegetable products and nonlipolytic enzymes have been applied to improve the extractability of oil from seeds (17, 18). In addition, the use of dense gases such as supercritical carbon dioxide is becoming increasingly important for the extraction of "natural" ingredients or for the dealcoholization of beverages as well as for enzymatic reactions (19). Furthermore, immobilization methods such as immobilization of enzymes or entrapment of microbial or plant cells provide effective means to ease the separations of biocatalysts and the desired products (20).

Product characterization, quality control and product safety are essential parts of any food processing operation. Besides the use of traditional methods to ensure quality and safety of foods and to identify food components, the increasing number of analytical methods involving enzyme reactions as well as the developments in bioselective electrodes will gain acceptance in the food industry. In addition, the potential of tissue culture and genetic methods for nutrient and toxicity assessments as well as the developments of freshness indicators (i.e. via monoclonal antibodies) are important potential aspects in the area of food safety. Regularly, aspects of biotechnology and food safety will be crucial for the future impact of biotechnology and food processing.

Treatment and utilization of food process wastes involves large volumes which create a disposal as well as a pollution problem. For example, 20 million metric tons of whey which contains about one percent protein and five percent lactose, accumulate annually in the US alone of which approx. 50% are disposed of in industrial or municipal waste treatment operations. This provides a major challenge for the biotechnologists to identify effective uses for the bioconversion of these waste products such as enzymatic hydrolysis of lactose (21, 22).

Bioconversion of food processing waste also includes the use of polysaccharide substrates such as potato starch or crab shell chitin. The application of molasses or corn steep liquor as substrates are other examples of waste utilization. Even the production of vinegar from "waste" wine can be placed into this category. Finally, the anaerobic digestion of food wastes to provide methane needs to be mentioned.

CONCLUSION

It has been attempted to provide some scattered examples on the impact of biotechnology of food production and processing. This and the realization of the impact food technology historically had on biotechnology should help to appreciate the magnitude and importance of what we now consider as "food biotechnology" (23).

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