Why Biotechnology
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43rd Autumn Conference - 25th/26th October 1998

Why biotechnology?

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The food processing industry is driven by the need to meet consumers' expectations for quality within an acceptable price envelope These drivers of cost, quality, safety and increasingly environmental performance will lead to the application of new scientific knowledge and technologies.

Modern biotechnology, genetic modification and associated techniques (derived from enzymology, fermentation, physiology biochemistry and immunology) open up the possibility of mild, specific very directed methods of processing. Also in the area of product variety, modern biotechnology opens up the way to new foods and foods that offer considerable quality advantages.

There are basically three ways in which genetic modification can contribute to the processing of food:

• **Plant biotechnology** makes it possible to upgrade raw materials in the plant itself. The gap between plant and desired products is reduced.

• **Micro-organisms** used in food processing can be improved in such a way that they are freed of their negative properties and tailored for specific tasks.

• **Enzymes** and enzyme systems can be optimised for a more specific upgrading of raw material, often with reductions in environmental impact.

One of the most important aids in food processing is the use of enzymes. Most industrial enzymes are produced by micro-organisms.

Total revenue in 1995 for industrial enzymes in the EU is estimated to have been $450 million. The figure is forecast to reach $900m by 2003. The overall price of industrial enzymes decreased between 1993 and 1996 and this trend is set to continue. Due largely to an increase in the production of enzymes by genetic modification techniques, larger quantities arc being produced in a more economical manner.

Proteases currently account for 34.4%' of overall revenues, but by 2003 lipases are forecast to he 38.5%'. The carbohydrates market is second at 30.5%

Main reasons for using genetic modification in enzyme production are:

• improved efficiency over expression of a given substance can substantially reduce product costs through reduction of energy costs, raw materials and waste.

• availability of traditional products such as chymosin

• availability of ‘new’ enzymes such as phytase for the degradation of phytic acid, an anti-nutritional compound found in crops such as soya

Tire use of genetic modification to produce enzymes helps to provide consistency of food quality, expands the variety of food products, enhances their digestibility and holds down production costs. For’ example, if chymosin was removed from the market this would increase the cost of cheese production and some cheeses may even disappear from the market

An enzyme which turns starch to fructose sweetener would impact on the price of sweeteners. Amylase improves bread quality, staying soft for the second day after purchase. Dairy products can be eaten by those with a lactose intolerance thanks to enzyme degradation. Enzymes are efficient processing aids - they can make the process easier and cheaper. They are biological catalysts that can replace chemicals, are 100% biodegradable and leave no harmful residues. They reduce the use of raw materials and energy, reduce the amount of water required in various processes and decrease organic waste.

Science has a fundamental role to play in the challenge to find solutions to rapidly growing world population and increasing personal consumption . The products and processes of tomorrow must not only be safe and meet consumer need they must also be based on materials and methods combined in ways which contribute to a sustainable future. Modern plant biotechnology is here to stay, and it will be a key technology in rising to these challenges.

To date most commercial developments in plant biotechnology have been based on agronomic benefits for example the antisense GM tomato. However, the

application of transgenic technology and an understanding of the genetic make-up of crops opens up options for improving varieties for quality and yield, and alternatives to traditional food processes.

Comparison of production and downstream processing requirements of

α ga1actosidase produced by standard and modified yeasts

	Standard yeast	*Modified yeast*
Production		
Yeast required	236 tonnes	10 tonnes
Waste required	2000 tonnes	90 tonnes
Waste yeast	400 tonnes	12 tonnes

Downstream processing

Ammonium sulphate	1100 tonnes	25 tonnes
Potassium sulphate	25 tonnes	1 tonne
Aluminium gel	1 tonne	None
Filtration aid	133 tonnes	5 tonnes
Solid waste	540 tonnes	18 tonnes
Liquid waste	1125 tonnes	26 tonnes
Demineralised water	3700 m^3	50m^3
Ice water	52000m^3	2000 m^3
Energy	44500kW	9000kW
Steam	220 tonnes	30 tonnes

In order to achieve quality improvements, food manufacturers are increasingly interested in the functional properties of foods. Functionality determined by a combination of the structural composition of the food and the small molecule ingredients in the food. The understanding of the molecular determinants of functional properties allows a rational approach to quality improvement. The understanding of this relationship makes it possible to define the function and structure of ingredients, which allow a targeted search for the source. This can lead to modifications in basic plant components, and also in textures and flavour.

Some work nearing the market on oil composition concerns high stearic (rape-seed) oil. It is possible to provide material for fat manufacture which does not require catalytic hardening - a normally harsh chemical treatment leading to undesirable by-products in the form of trans fatty acids - so simplifying processing eliminating unwanted by-prod nets and reducing environmental impact.

Functionality can also be viewed in terms of nutritional quality. Nutrition and safety has been a strong force in innovation and this is set to continue There are major challenges provided by the advances in nutrition science and the understanding of functional molecules. Couple this with the demographic changes in the developed world, and these forces are all directing the market for health foods.

The emphasis in functional foods is shifting from ‘removing the bad’ (for example lower salt, cholesterol) to ‘enhancing the good’. The nutritional value of products and effects on diet and health are increasingly of concern both to consumers arid overburdened health systems. Consumers are looking to modulate their diet with foods which are considered to support a healthy lifestyle. The elimination of antinutritionals and allergenic compounds, and

augmentation of nutritional molecules, such as vitamin and antioxidants, are obvious targets for development.

'Functional foods', sometimes called nutraceuticals, are already finding their way on to the market The US market is forecast to double in the next five years, mainly fuelled by the health consciousness of the US consumer. Nutritional and medical research into the relationship between diet and human health is the pillar on which much of the US nutraceutical market rests. Universities, in particular Harvard and the University of California at Berkley, hospitals and other governmental institutions are very active contributors to the growing pool of nutritional information. Take the recent study on Alzheimer's disease, where high doses of vitamin E were shown to delay the onset of memory loss (the vitamin was already popular because of its potential in preventing cardiovascular problems). Nutraceulicals include vitamins, minerals, oligosaccharides, fatty acids, antioxidants, phytochemicals, botanicals, herbals, sugar alcohols, amino acids, specific peptides and proteins and dietary fibre. In the US, even fat rep1acers are sometimes included in this group. Of the above, probably the most interest surrounds antioxidants, essential fatty acids, peptides and probiotics. Antioxidant systems may be put together for specific diets which could be targeted to offer different levels of protection to different organs. The essential omega-3 fatty acids may soon be produced by fermentation substituting for fish oil.

Certain proteins are difficult to digest - in some cases their enzymic breakdown becomes more difficult with age. Pre-digestion of proteins and carbohydrates could help an ageing population.

Specific amino acids are also important. Diets low in glutamine can result in degenerative changes in the intestinal mucosa with consequent malabsorption.

Isoflavones found in soybeans promise a uniquely broad array of benefits, cutting cholesterol better than low fat diets alone can, preventing post-menopausal bone loss and lowering the risk of prostate, breast and other major cancers.

Another challenge to the food producer is to make and market products with enhanced organoleptic attributes with which to compete for market share. There is no shortage of potential targets in the area of modification of food texture, for example via the manipulation of developmental processes in plant cell walls, or targets related to flavour generation or

colour or preservation characteristics.

The difficulty in improving these qualities is that there is an insufficient understanding of the linkage between genes and quality attributes. Thus, the current search is for practical goals which enable improvements in quality to have a real impact on consumer products.

Therefore, research is increasingly being devoted to the development of tools to modify the behaviour of genes controlling food textures, flavour, colour, combined with preservation methods and nutritional qualities. To this is coupled a suite of tools for analysing market trends, mapping consumer preference on to product attributes, understanding the cognitive basis of choice and mapping sensory awareness on to the qualities of ingredients. The challenge is to bring all of these tools together in a constructive network to define opportunities and targets for novel traits.

However, functional foods, ingredients or nutraceuticals, for example cholesterol lowering products, are to find a way on to the market, the food industry will need to communicate its work to a public bewildered by the pace of technological change arid nervous and suspicious of many of the breakthroughs.

Innovative food manufactures will need to he proactive in giving information about products in order to satisfy, and hopefully delight their consumers.

Main brand manufacturers like retailers are aware of their consumers. A company will only be successful if a consumer buys its products in preference to that of a competitor and does it again and again. The only way companies stay in business is if the consumer buys the products. Ultimately. industry will only benefit if the consumer benefits.