Modern biotechnology in food: Modern biotechnology and food quality

06 August 2006

In Europe, a vast diversity of high quality foods provide the carbohydrates, fats, proteins, minerals and vitamins needed in the everyday diet of consumers. At the heart of food production is biotechnology. One aspect of biotechnology which has been used for centuries is the selective breeding of crop plants and farm animals to produce improved food. Another is fermentation, in use for millennia to produce fermented foods like cheese, bread, beer, sauerkraut and sausages.

The first use of gene technology two decades ago opened up the potential for many additional advances in both selective breeding and fermentation. Each specific step forward might be relatively small, but together they could add up to further improvements in the nutritional quality, appearance, flavour, convenience, cost and safety of foods.

Better raw materials

In improving raw food materials, many plant breeding programmes have been directed towards boosting yield or allowing more environmentally compatible agriculture by increasing the resistance of crops to viruses, pests or herbicides. Increasing yield has clear benefits in helping to feed the worlds ever-increasing population and could provide cheaper food. Plants which are resistant to attack by insect pests and diseases would need fewer pesticide applications; resistant crops such as maize, tomatoes and potatoes are already being developed. Crops have also been produced with tolerance to modern, more environmentally compatible herbicides, with the aim of achieving optimal weed control with reduced levels of herbicide.

Today, there is increasing interest in improving the nutritional value, flavour and texture of raw materials. This could help encourage greater fruit and vegetable consumption in line with government guidelines on healthy nutrition.

A range of promising crop plants are being developed with:

- Improved nutritional value - Crops in development include soybeans with a higher protein content; potatoes with more nutritionally available starch and with an improved amino acid content; pulses such as beans which have been altered to produce essential amino acids; crops which produce beta-carotene, a precursor of vitamin A; and crop plants with a modified fatty acid profile. An example is a strain of oilseed rape which produces a special type of polyunsaturated fatty acid (the so-called w3-fatty acids). These have been linked to brain development and have potential in a range of speciality, clinical and infant foods.
- Better flavour - For example, types of peppers and melons with improved flavour are currently in field trials. Flavour can also be improved by enhancing the activity of plant enzymes which transform aroma precursors into flavouring compounds.
- Improved keeping properties with the aim of making transport of fresh produce easier, giving

consumers access to nutritionally valuable whole foods and preventing decay, damage and loss of nutrients. Examples include the improved tomatoes now being sold in the US, and recently approved in the UK, which have been genetically altered to delay softening. Research is underway on making similar modifications to broccoli, celery, carrots, melon and raspberries. The shelf-life of some processed foods such as peanuts has also been improved by using raw materials with a modified fatty acid profile.
- Reduced levels of toxicants, allowing a wider range of plants to be used as food crops, such as the edible strain of sweet lupin which has been developed through conventional breeding techniques.

Improved food ingredients ...

Necessary changes to the key food ingredients, starches and oils, are usually made by processing. Biotechnology opens up the possibility of altering crop plants to produce exactly the type of ingredients needed:

- Starches- Plant breeders have introduced a bacterial gene into potato plants which increases the proportion of starch in the tubers whilst reducing their water content. This means that the potatoes absorb less fat during frying, giving low-fat chips. Sweeter potatoes have also been produced which have a higher sucrose content than traditional varieties.
- Oils- Both rapeseed and sunflower are being altered to produce more stable and nutritious oils, which contain linoleic acid instead of linolenic acid and have a lower saturated fat content. Rapeseed has also been modified to produce a high-temperature frying oil low in saturated fat.

Advances in processing and additives ...

Research underway at present aims to allow the production of better food raw materials by crop plants. However, some processing steps remain essential to bridge the gap between currently-available raw materials and the desired end-product.

Traditional biotechnology has played a major role in producing fermented foods - where desirable changes are produced by the action of micro-organisms or enzymes - of which over 3,500 different types exist around the world. In Europe and North America, bread, yoghurt and cheese are perhaps most familiar. In Africa, foods made from fermented starch crops like yams and cassava are more important, whereas in Asia, products derived from fermented soya beans or fish predominate.

Fermentation can make the food more nutritious, tastier or easier to digest, and it can enhance food safety. It also helps to preserve food and to increase its shelf-life, reducing the need for additives. Genetically improved strains of microbes can make a major contribution to these desirable properties.

For many years, a wide range of additives, processing aids and supplements have been obtained from microbial sources by fermentation. Increasingly, modern biotechnology is being used here. Products include vitamins, citric acid, natural colourings, flavourings, gums and enzymes. Gums used as low-calorie thickening agents and low-calorie sweeteners from natural ingredients are also produced using modern

biotechnology. Enzymes (see separate background paper) - the naturally-occurring catalysts responsible for literally all the biochemical processes of life - are used in applications such as bakery and cheese making to improve texture, appearance and nutritional value, and to generate desirable flavours and aromas.

A second area where biotechnology has advantages is in improving the processes by which food is produced. Here, it can be used to develop mild, highly specific processes using modified micro-organisms and purer, cheaper enzyme products. These can offer better productivity, cost-effectiveness and energy efficiency than existing processes. They can produce top-quality foods with a reduced need for additives such as flavourings, and can also reduce the environmental impact of food processing.

Specific areas of food processing where advances are being seen are:

- Bread-making, for which improved strains of yeast have been developed containing genes for production of other food processing aids, such as amylases, which give improved dough. Yeast can also be used to produce a range of enzymes for use in processes such as cheese production, where introducing a copy of a calf gene has given a strain of yeast which produces the enzyme, chymosin. Previously, this enzyme could only be obtained from the stomachs of calves.
- Fruit juice production, where juice yields from apples can be improved by adding pectinase enzymes. These are produced naturally by a strain of the mould Aspergillus. The rate at which the enzymes are made can be improved by transferring the gene for pectinase from one strain of the mould into a second strain with a higher capacity for enzyme production.
- Improved quality management and food safety, through a greater understanding of micro-organisms and enzymes in food production. A range of biological tools, such as monoclonal and polyclonal antibodies, will add to this impact through their use in a range of diagnostic tests aimed at enhancing the quality and safety of products and processes. These can potentially be used to monitor the presence of additives, toxins, pesticides, micro-organisms and antibiotics, and they will give quicker, more accurate detection than traditional laboratory processes.

Biotechnology - a definition

Biotechnology is any technique which uses living organisms or their components to make or modify products, to improve plants or animals or to develop micro-organisms for special uses.
Source: OECD

Gene technology - a definition

Gene technology includes any technique for the controlled modification or transfer of genes from one organisms to another to give a desired characteristic.