Application of gene technology to improve nutritional value of plant-based foods

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Recent developments in gene technology, combined with traditional plant breeding, are providing powerful means for modifying the composition of plant products to improve their nutritional value. These technologies will be instrumental in the development of a range of nutritionally-enhanced plant products and functional foods derived from them. Nutritional improvements can be achieved by genetically altering the composition of existing major constituents (such as proteins, oils and starches), by incorporating new nutritionally-desirable constituents (such as vitamins and antioxidants), and by removing antinutritionals factors (such as toxins and allergens). Recent achievements in enhancing the nutritional value of oilseeds provide excellent examples of these approaches.

Fats and oils are a major component of the human diet, and there has been considerable attention in recent decades on studying their impact on human health, particularly their involvement in cardiovascular disease, cancer, and various inflammatory conditions. This has led to a clearer understanding of the beneficial and detrimental components of fats and oils. Various gene technology approaches have now been used to modify the relative proportions of these components to improve the nutritional value of oils while retaining the functional properties required for various food oil applications. Major alterations in the proportions of individual fatty acids have been achieved in a range of oilseeds using conventional selection, induced mutation, and more recently, post-transcriptional gene silencing (PTGS). In particular, a number of high-oleic oils have been developed in order to provide high-stability cooking oils. These oils provide the opportunity to replace the current widespread use of saturated fats and hydrogenated oils that contribute significantly to increased risk of cardiovascular disease due to the effect of saturated and trans-fatty acids on elevating LDL cholesterol in the bloodstream. Similarly, oils with increased stearic acid content are being developed to enable the production of solid fats without the need for hydrogenation.

Omega-3 fatty acids play a critical role in brain function, the maintenance of membrane structure and function, the regulation of cholesterol synthesis and transport, the prevention of water loss from the skin, and serve as precursors of eicosanoids, including prostaglandins and leucotrienes. Today, the main source of the long-chain omega-3 fatty acids, eicosapentaenoic acid (C20:5; EPA) and docosahexaenoic (C22:6; DHA), are the oils of fish and other marine organisms. The global supply of fish is declining and projected to be insufficient to meet future world dietary requirements. Gene technology is now being applied to transfer genes controlling synthesis of long-chain omega-3 fatty acids from various microorganisms into plants, thus potentially expanding their availability in the human diet.

Nutritionally beneficial improvements in minor constituents can also be achieved using gene technology. Canola and mustard oils with enhanced levels of pro-vitamin A (beta-carotene) are already being developed and, along with the similarly developed ‘Golden Rice’, offer great promise for alleviating Vitamin A deficiency in developing countries. Similarly, antioxidant levels have been successfully altered in plants using gene technology. For example, the balance of the various forms of tocopherols has been shifted towards alpha-tocopherol, the form which is most important in human health.