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Utility of Biotechnology to Oil and Fats Industry.

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ABSTRACT

Utility of the several techniques of modern biotechnology, including various approaches towards genetic modification, have allowed the development of several genetically modified (GM) crops. A lot of progress has been made in the area of plant breeding and modification of certain plant traits based on a fuller and better understanding of the plant genome. It is important in the present status and for the future potential of biotechnology to crop modification and its relation to oils and fats industry be assessed in terms of actual realities rather than those of wishful expectation. From the last three decades, variety of techniques have been introduced and developed for in genetic modification of plants. Acceptance of GM crops has not been universal. The technology for modifying the plant genome to produce consumer desirable products is available and is evolving. Concern among individual government and national consumers are having major impacts on further applications of these crop varieties and their global trade.

Keywords: oil, fats, plant

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INTRODUCTION

The introduction and development of a variety of techniques for use in the genetic modification of plants occurred primarily in the 1980's and early 1990's which has been documented [1, 2]. In the present decade the trend has been towards refinement of developed procedures and the introduction of some new innovative approaches [3, 4]. The socio-economic aspects are considerable and are having major impacts that need to be addressed before further definite advances can be made.

The evolution of techniques for the genetic modification of plants has progressed through conventional breeding programs, mutation breeding, transgenic technology and attempts to regulate gene expression by approaches such as gene silencing.

PLANT ENGINEERING:

Plant stock evaluation, characterization of the diversity of germplasm and identification of quantitatively inherited traits has been made routinely by one of the several techniques of molecular biology. Several approaches have been taken in attempts to modify plant behavior in such a way as to unmask or to introduce some desired characteristics. Mutagenic agents such as ionizing radiation or chemical mutagens including sodium azide and ethyl methane sulphonate act to unmask traits normally hidden in the wild plant. Use of the technology has been made in mutation breeding and has enjoyed some general successes, but is being replaced by other more efficient technologies [5].The hit and miss modification of the genome and the high dependence on suitable screening methods have proved to be limiting factors in more regular use of this technology.

Foreign DNA responsible for a particular trait requires methods for its preparation before transference into a host plant cell. In general procedure exist for the isolation of the desired DNA material, preparation of cDNA for encoding the required enzymatic activity and cloning of DNA in E.coli [3, 4].Various practices have been employed for the introduction of foreign DNA into the host plant which are as follows:

- Transfection where certain bacteria such as agro bacterium tumefaciens and viruses are used as vectors to carry a desired DNA fragment into the host cell.
- Electroporation where a transient increase in host cell membrane permeability caused by brief voltage pulses allow uptake of desired DNA material from the medium.
- Microprojection where very small particles of tungsten or gold coated with the desired DNA is shot into the host cells with a high-velocity "gene-gun".

Several approaches have been taken for the modification of a single key enzyme system. The choice of enzyme system to be targeted reflects the specific activity associated with fatty acid biosynthesis or fat formation. The techniques used in targeting specific enzyme systems have included:

- Site-directed mutagenesis whereby enzyme activity is modified through molecular change, generally at active site, induced by the introduction of appropriately synthesized DNA material.

- Anti-sense technology where a system is provided with a chemically synthesized RNA fragment that is complementary to the mRNA of the targeted enzyme resulting in decreased quantities of sense mRNA through its removal by hybridization with anti-sense RNA.The lower quantity of the sense-RNA for translation results in decreased production of targeted enzyme.

- Gene silencing technology where naturally occurring short-interfering RNA's short-temporal RNA's or micro RNA's may be available to target mRNA for the targeted enzyme for silencing by complementary base pairing [6].

All these approaches to alteration to the plant genome and modification of the activity and level of targeted enzymes are heavily dependent upon accurate knowledge of plant genetics and lipid chemistry (table 1).

Table 1: Some available transgenic crops and their trait modification.

CROPS	ALTERED TRAITS
Canola (Brassica napus)	Glufosinate ammonium tolerance*
	Glyphosate tolerance*
	High lauric
	High-stearate/low-polyunsaturate
	High oleic
	High medium chain
Soyabean (glycinemax)	Glyphosate tolerance
	High oleic/low-saturate
Corn (zea mays)	Bt-resistant***
	Glufosinate ammonium tolerance
	Glyphosate tolerance
Cotton (Gossypiumhirasutum)	Bt-resistant
	Glyphosate tolerance
Flax (Linumusitatissimum)	sulphoylurea tolerance

*** Liberty Link, ** Roundup Ready, *** Bacillus Thuringiensis Adapted from Haumann (1997)**

GENETICALLY MODIFIED OILSEED CROPS:

Major attention has been paid to the development of herbicide-resistant and insect-tolerant varieties. Apparently little attention has been obtained in increasing the total lipid yield in any commercial genetically modified crop. Conventional varieties of canola/rapeseed, groundnut/peanut and linseed (flax) provide on average seeds with approximately 45% of the dry mass as lipid. The large use of soyabean oil reflects high cultivation of soyabeans that provide beans with approximately 20% lipids. Palm oil and coconut oil continue to provide relatively high yields of oil, 60-70%, that are proving to be invaluable in meeting the dietary needs of many emerging nations.

The observation that certain non-domesticated plants can accumulate up to 70% oil of seed bio-mass suggests that molecular mechanism for greater oil accumulation do exist and may be available for incorporation in transgenic crops.

Some definite successes have been achieved with genetically modified varieties that have been engineered to provide modifications in the fatty acid compositions of several oils. These varieties have been developed primarily to meet the perceived human nutritional needs and the demands of food industry. The earlier practice of partial hydrogenation of vegetable oil with desired rheological properties is presently under scrutiny due to the process producing a significant quantity of trans fatty acid that are regarded as a potential health hazard to humans. As a result a market exists for oils that have the required saturated fatty acids composition that could be obtained from blends or direct production from an appropriate genetically modified crop.

Consideration has also been given to the introduction of potentially more human healthful oils. Thus, genetically modified varieties of high-oleic canola, soyabean, sunflower seed and peanut oils have been developed but their immediate market may be limited by the availability of natural high-oleic oils such as olive oil. Application of techniques of the hairpin RNA-mediated post-transcriptional gene silencing to down-regulate the seed expression of two key desaturase gens has allowed the production of genetically modified cotton varieties, yielding oils one enriched in stearic acid at 40% of total fatty acid component and the other containing up to 77% oleic acid [7].

The nutritional value of polyunsaturated fatty acids (PUFA) with due regards to the relative presence of n-6 and n-3 fatty acids components in the oil presents a challenge for the development of new crop varieties. Some successes have been achieved by the introduction of the appropriate genetic information, generally from non-plant sources, for the bio-synthesis of PUFA [8].Further approaches have been made to produce the appropriate genes for the synthesis of specific PUFA's that are present in animals. The choice of host oilseed species is important for the provision of the necessary unsaturated fatty acid substrate for appropriate enzymatic conversion to the desired n-3 or n-6 PUFA in the transgenic plant Thus soyabean would be a preferred host plant for the formation of n-6 PUFA's and flax for n-3 PUFA biosynthesis. The process is extremely complex requiring not only the genes encoding for the desired enzymes, but also coordination and regulation of their respective activities. Research is still going on in this area.

Certain plants possessing unique fatty acids in their seed oils are under active consideration as source of industrially useful oleochemicals. Among plants attracting attention are cuphea for short/medium chain fatty acids, lesquerella for long chain hydroxy acids and stoke aster for epoxy fatty acids. Erucic acid is another fatty acid of interest for, in addition to serving as a component of the diet of several people in Asia and India, high–erucic acid rapeseed oils have a good potential for industrial applications. Moreover, there is increasing interest in the use of genetically modified high oleic oils as the basis for bio-lubricants [9]. The attractiveness of alternate crops as renewable sources of feed stocks for the oleochemical; industry is liable to receive a considerable boost from increasing interest in biodiesel.

SOCIO-ECONOMIC CONSIDERATIONS:

A study released in 2001 by the International Service for the Acquisition of Agri-biotech Applications indicated that definite benefits resides with the use of genetically modified crops [10]. There has been an approximately 30-fold increase in the use of genetically modified crop variety over the time period 1998-2006.The major planting has been made In United States, Argentina, and Canada with significant increased activity in China since 2000.

The major opinion held against genetically modified crops is the lack of any apparent benefits to the consumer. To this extent food derived from genetically modified crops is deemed unacceptable, whereas the production of medical goods via bio-pharming or the production of oleochemicals for industrial use is considered to be more acceptable. Health risks including possible allergenic responses and the adverse effects on the environment are the most frequently voiced factors in the opposition to genetically modified crops. The use of genetically modified crops for the production of biopharmaceuticals is believed to have high potential [11].

CONCLUSIONS

The technology for modifying the plant genome to produce consumer desirable products is available and is evolving. At the present stages of development commercial successes have been limited. The availability of herbicide-resistant and insect-tolerant crop varieties has been of some definite advantage to the producers, but has not been perceived by many consumers to provide any worthwhile benefits. The production of products ranging from oils of defined fatty acid composition that is desirable for use in human nutrition or for the provision of feedstock for industrial purposes. Caution must be offered, however, that bio-technology by itself is not a panacea to meet the feeding of the hungry or to provide the local farmer with a dignified income. Biotechnology has a role to play in advancing the universal standards of living. Success, however, will be dependent upon a tripartite approach involving Academia, providing the required science, Industry in supplying consumer-desirable products, and government in implementing the appropriate legislation to ensure that the common good is met at all times.

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