Tobacco Tech

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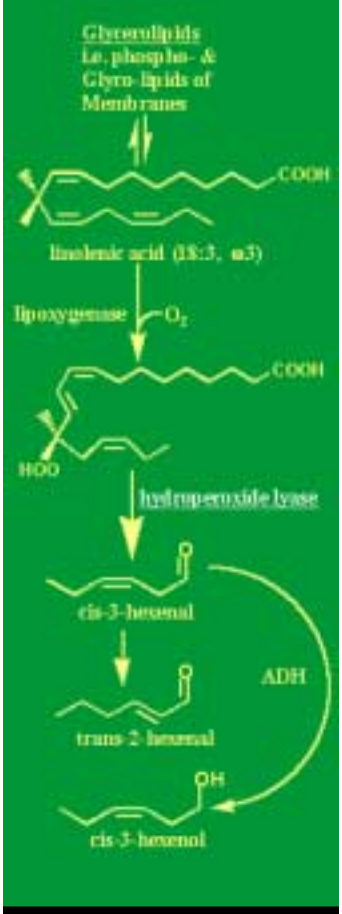

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Natural Compounds From Tobacco: A Potential New Growth Market

Plants are an important source of natural chemicals and materials such as flavorings, fragrances, medicines, dyes, rubber and oils. Over time and with the benefit of many thousands of species of plants from which to produce them, countless numbers of such natural substances have found their way into consumer products.

A THRI-sponsored project led by Dr. David Hildebrand in the U.K. College of Agriculture is looking at genetically engineered tobacco as a consistent new source of such natural materials; in particular, flavor and fragrance compounds. Many flavor and fragrance compounds are now chemically synthesized, but there are increasing demands for natural materials, both as end products and also as building blocks for many of the synthetic compounds that are produced. The source of many of these natural substances can be uncertain. With non-commodity sources such as trees, shrubs, flowers or as by-products (e.g. orange peels or watermelon leaves) the quantity and quality of such materials can be quite variable. By adding or deleting genes in a tobacco plant, it is possible to alter the characteristics of natural plant compounds to make tobacco a high-level "factory" for valuable flavors and fragrances.

Leaf aldehyde (trans-2-hexenal) and leaf alcohol (cis-3-hexenol) are two of the substances that have significant market potential for production in genetically engineered tobacco leaves. These compounds are used in a wide array of beverage products such as wine coolers and softdrinks as well as in various food products where fresh or fruity aromas are desired.

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Identity Preservation: a Key Component of New Variety Development

It is highly unlikely that tobacco engineered for the production of new products such as pharmaceuticals, enzymes and other valuable materials would become co-mingled with conventional tobacco. Tobacco for molecular farming is harvested while green, prior to maturity, and in most cases is harvested several times per year. For this value-added

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Conventional breeding and biotechnology-based options are being used to develop new tobacco varieties for molecular farming. Varieties, like the one pictured above, may have useful characteristics for molecular farming and are also easily distinguished from tobacco used in traditional markets.

Identity Preservation

crop, the profits may often be higher compared with conventional tobacco, providing economic incentives to make sure that molecular farming products reach their intended markets.

However, there is a concern to guarantee that co-mingling of specialized crops cannot occur. (Recently, for example, a food variety not approved for human consumption entered the food production path unexpectedly). Fortunately, just as biotechnology enables the development of new plants with useful new properties and applications, it can also be applied to distinguish them.

It is a relatively simple matter to ensure that tobacco varieties developed specifically for new, molecular farming applications exhibit a distinctly different appearance from tobacco grown for traditional uses. Currently both conventional breeding and biotechnology-based options are under investigation and development by researchers at THRI.

The arrows in the picture above indicate areas in the leaf where ripening or senescence has been delayed. This trait could be used to develop molecular farming varieties which stay very green both in the field and when cured.

For example, efforts to develop new tobacco varieties specifically for molecular farming include screening many "wild-type" tobaccos for useful characteristics (e.g. cold tolerance, seedling vigor, gene expression, disease resistance, and protein content). Currently 47 tobacco species (one example is shown on the front page) are included in this evaluation. Many of these exhibit distinctly different appearance in terms of stature, appearance of the foliage, etc., when compared with conventional burley tobacco. Special attention will be given to developing molecular farming varieties which exhibit these distinct characteristics.

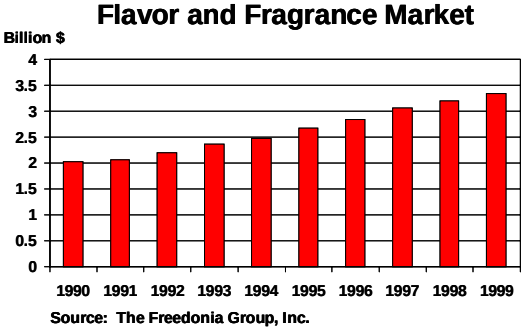
A biotechnology strategy (leaf shown on this page) provides an alternative segregation trait. Tobacco plants normally turn yellow when they are stressed or as they get older. This ripening process, called senescence, is desirable for conventional tobacco, but may be detrimental for molecular farming.

Dr. Susheng Gan is developing an anti-senescence system in tobacco. One benefit of this trait is that plants engineered for delayed senescence would stay green much longer in the field and not "cure out" like conventional tobacco (cures very green). This would provide one potential visual method of segregating "molecular farming" tobacco in the field and also when cured. Many other biotechnology strategies could also be developed as identity preservation traits.

Flavor and Fragrance

Prices for leaf aldehyde and leaf alcohol vary, but currently are in the range of $37 to $90 per pound. Other potential flavor/fragrance substances that could be produced in tobacco leaves have prices over $200 per pound illustrating the high value of these natural products.

In addition, the flavor/fragrance industry has experienced significant growth over the past decade (see market graph below) with demand increasing from just over $2 billion in



1990 to almost $3.5 billion in 1999. Considering the enormous number of current and potential uses for flavorings and fragrances, it is hard to imagine a reversal of this trend. Producers of food and drinks, perfumes, deodorants, shampoos, toothpastes, air fresheners, laundry soaps, detergents, cleaning agents, pharmaceuticals, as well as numerous additional products, use these additives to make their products more appealing. At THRI one of our goals is to develop new technologies and production systems so that tobacco can be economically used to produce valuable materials like flavors and fragrances. The objective is to create new market opportunities for Kentucky tobacco producers.

TOBACCO TECH is an occasional series published by THRI to inform growers and others about exciting new possibilities for tobacco. Topics will provide information on our cutting-edge biotechnology research program and our efforts to stimulate new crop opportunities for Kentucky tobacco farmers.