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Review

Genetically modified plants for non-food or non-feed purposes: Straightforward screening for their appearance in food and feed

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ABSTRACT

Genetically modified (GM) plants aimed at producing food/feed are part of regular agriculture in many areas of the World. Commodity plants have also found application as bioreactors, designated non-food/non-feed GM (NFGM) plants, thereby making raw material for further refinement to industrial, diagnostic or pharmaceutical preparations. Many among them may pose health challenge to consumers or livestock animals, if occurring in food/feed. NFGM plants are typically released into the environment, but are grown under special oversight and any among several containment practices, none of which provide full protection against accidental dispersal. Adventitious admixture with food or feed can occur either through distributional mismanagement or as a consequence of gene flow to plant relatives. To facilitate NFGM surveillance we propose a new mandatory tagging of essentially all such plants, prior to cultivation or marketing in the European Union. The suggested tag – Plant-Made Industrial or Pharmaceutical Products Tag (PMIP-T) – is envisaged to occur as a transgenic silent DNA identifier in host plants and designed to enable technically simple identification and characterisation of any NFGM. Implementation of PMIP-T would permit inexpensive, reliable and high-throughput screening for NFGM specifically. The paper outlines key NFGM prospects and challenges as well as the PMIP-T concept.

Contents

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1. Introduction

Genetically modified (GM) plants, developed for the production of food and/or feed, have been on the international market since the mid-1990s. In general a single transgene conferring agricultural advantage, such as insect resistance, herbicide tolerance or growth in otherwise troublesome conditions, has been added to the plant (Dunwell, 2005; Morin, 2008). Hybrids between two such GM plants, harbouring two of more transgenes, have also reached the market (Dunwell, 2005; Umezawa et al., 2006). In recent years also nutritionally improved GM plants with changes of benefit to the consumer have been commercially explored, such as oil-rich plants with healthier fatty acid composition and maize with a changed amino acid balance (Bicar et al., 2008; Newell-McGloughlin, 2008; Truksa et al., 2006).

Since the early 1990s, and especially over the last decade, another type of genetically modified plants, engineered to produce non-food proteins or metabolites for industrial or pharmaceutical use, has found substantial commercial attraction. In many cases common food- or feed plant species such as potato, carrot, soy bean, rice, tomato and papaya provide production platforms for such products. Major incentives behind this development include well established cultivation technologies in agriculture and, for several among them, extensive knowledge on protein expression mechanisms and methodologies for plant transformation (Sparrow et al., 2007; Twyman et al., 2005). Within the scientific and regulatory literature this phenomenon is referred to as "biopharming" or "molecular pharming" and the plants are commonly designated "pharma plants" or "non-food/non-feed GM plants" (NFGM). They are typically modified to express anyone among a broad range of proteins, such as immunoglobulins, cytokines, enzymes and hormones or viral capsid proteins for the production of vaccines (Agarwal et al., 2008; Bouche et al., 2003; Hernandez et al., 2007; Jiang et al., 2007; Lou et al., 2007; Moravec et al., 2007; Richter et al., 2000; Sardana et al., 2007; Walmsley et al., 2003). Major incentives for an increased commercial interest in plant biopharming lie in its scalability and dramatically lower production costs for the raw material, relative to fermentation-type manufacturing procedures (Twyman et al., 2005). Furthermore, the plant cell physiology enables post-translational processing of complex mammalian proteins resembling that of human cells, which is essential to the authenticity of transgenically expressed human biosimilars (McCormick et al., 2008; Sparrow et al., 2007). Upon ingestion, certain NFGM plants, or components derived thereof, may exercise negligible or modest adverse effect on consumers or livestock animals, whereas other varieties may be clearly toxic or otherwise highly inappropriate in food or feed (Kirk et al., 2005; Sparrow et al., 2007; Twyman et al., 2005). Because of perceived difficulties to accomplish complete separation from food or feed chains at all stages of growth, harvest and transportation the development of such plants raises concern for inadvertent admixture of conventional foods and feeds with NFGM plant material or its processed products. In addition, there is a risk of vertical gene flow to domesticated or wild relatives. These potential hazards translate to an increased need for risk management of NFGM plants and products obtained thereof.

In this paper, we present a brief review on various regulatory challenges in relation to risk management of conventional GM and NFGM plants, with a broad view to human and animal health and the environment. Moreover, we propose and outline a novel detection, quantification and identification framework, specifically designed for NFGM plants. The aim is to substantially facilitate future monitoring and traceability of NFGM plants and products, i.e. to enable more straightforward, faster and cost-efficient monitoring relative to that reliant on standard GM event screening approaches.

2. Genetically modified plants in a regulatory context

Global guidelines for risk analysis and risk assessment of GMOs have been developed by the *Codex Alimentarius* Commission (CAC) in several documents. One of those, The Principles Document, advocates that a new GM food should be assessed for its safety by comparing it with a food with an established history of safe consumption, in order to identify potential hazards requiring further considerations. This view is typically referred to as the Concept of Substantial Equivalence. The aforementioned document also stresses that risk managers should take into account uncertainties identified in the risk assessment and implement appropriate measures to manage them (Codex, 2003). The CAC guidelines are internationally endorsed, although the GMO authorisation procedure differs across national jurisdictions, where such are in place.

Within the European Union (EU) at present seven Directives or Regulations govern the use of GMO in areas pertaining to food and feed (Table 1). The three central legal frameworks directly related to food and feed are Council Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms, Regulation (EC) No. 1829/2003 on genetically modified food and feed, and Regulation (EC) No. 1830/2003 pertaining to the traceability and labelling of genetically modified organisms and the traceability of food and feed products, produced from genetically modified organisms (EC, 2001, 2003a,b). The first two of these legal instruments stipulate a pre-market assessment of GMO and aims at securing market release only of those GMOs that are safe for humans, animals and the environment. A regulatory body, designated the Community Reference Laboratory for Genetically Modified Food and Feed (CRL-GMFF) and being part of the European Institute for Consumer Health and Protection within the European Commission's Joint Research Centre (JRC), was established under Regulation (EC) No. 1829/2003. Its main commitment includes scientific assessment and validation of detection methods for GM food and feed, which is conducted in collaboration with a network of European national control laboratories, assembled in the European Network of GMO Laboratories (ENGL). Prior to authorisation of any GMO in the EU, the applicant must present methods for detection, sampling and identification of the particular GMO event as well as samples of the food/feed and associated control samples.