GM and non GM supply chains: Their CO-EXistence and TRAceability

Outcomes of Co-Extra

When it comes to genetically modified (GM) food and feed, freedom of choice for everyone involved in the supply chain, from farmer to consumer, is a must.

It is just as important to find a way to grow and process GM, conventional and organic crops side-by-side (co-existence) as it is to be able to detect and trace GM organisms (GMOs) in the supply chain (traceability).

The EU Co-Extra project was set up to do just this by developing practical solutions for sampling, tracing, labelling and documenting the GM content of food and feed. Its goal is to facilitate co-existence for all stakeholders and to provide cost-effective and reliable tools, such as GMO detection and sampling methods, cost-benefit analyses of production line strategies and technical advice and strategies for enabling co-existence in the supply chain.

There were 52 partners from the industry, research institutes, universities and food/feed producers from 18 countries including EU Member States, Russia, Brazil and Argentina involved in the Co-Extra project which ran from 2005 to 2009. It was co-ordinated by Yves Bertheau of the French National Institute for Agricultural Research (INRA) and comprised eight work packages (contact details: see page 8).

Co-existence

To put it simply, co-existence is a way of allowing farmers, importers, food/feed processors, retailers and consumers to choose conventional, organic or GM production. Although many GMOs are authorised in the EU, only GM maize is currently commercially cultivated in some European countries. Increasing quantities of imported GM products, however, are arriving in our ports. Some of these products are authorised for commercial use in the EU, some are not.

European legislation was introduced in 2003 to control the introduction and production of GM goods. This legislation aims to promote transparency, information dissemination and freedom of choice. It calls for tools to aid all players in the supply chain in making conscious and informed decisions.

While this may all seem feasible enough, the practical implementation of co-existence throughout the supply chain presents a few challenges of its own, namely gene flow management, costs and methods of segregating GM and non-GM products, GMO detection and sampling, and liability and compensation.

Co-Existence in the field: gene-flow management

A major source of controversy in the public debate on co-existence is pollen flow. The fact that GM plants behave just like their conventional counterparts means that their pollen is dispersed by wind and insects, too. To allow for co-existence in the field, ways had to be found to inhibit GM pollen from contaminating conventional and organic crops. The Co-Extra project studied pollen flow factors and came up with different ways of reducing pollen flow.

Agricultural methods included establishing minimum isolation distances between GM and non-GM fields, planting for time-lag of flowering, growing buffer strips of conventional crops on the borders of GM fields, and controlling the fields post-harvest to remove GM volunteers – the second-generation growth.

Co-Extra focussed on biological containment methods such as male sterility, cleistogamy and inserting target genes in chloroplasts. No single strategy is applicable to all crops. Research was concentrated on Europe's most important crops: maize and rapeseed.

Maize tassels are normally full of pollen. Maize that is male-sterile, however, produces no pollen at all. Some naturally occurring plants are male-sterile, meaning they cannot produce functioning male flowers and thus release viable pollen. It seemed as if male-sterile maize would be the answer to preventing the spread of GMOs, but there is a major setback. Most crops need pollination to produce seed and fruit. Fields full of only male-sterile maize would never be practical. Without pollen, the maize ears would not be able to develop kernels. This could be overcome by mixing male-sterile maize with conventional maize that produces pollen. This non-GM maize would act as a pollen donor to the GM plants, but not be a problem to conventional crops in case of pollen drift.

An easy way to keep GM plants from releasing their pollen is to ensure that their flowers do not open. This phenomenon is what is known as cleistogamy and was also researched for its role in co-existence. Induced mutation was carried out on different lines of rapeseed flowers and most flowers of those cleistogamous lines remained closed. In some environments, though, a variable proportion of the flowers opened partially. While cleistogamy cannot completely eliminate cross-pollination, it has major potential for limiting it.

However, there is no indication of the rapid commercialisation by seed companies of these biocontained varieties.

Yet another way in which the pollen flow of GM plants can be inhibited is by a new technique of target gene insertion. Target genes are normally inserted into the DNA of the cell nucleus. Means have now been developed to insert a new gene into the chloroplasts. These plastids usually do not occur in the pollen cells of flowering plants.

Co-Extra work was also concerned with seeds. As the starting point in the food supply chain, seed purity is of utmost importance for ensuring co-existence in the field. Experiments of maize seed admixture were conducted to evaluate the effect of seed thresholds on the final out-crossing in the harvest product.

These technical measures could ensure that co-existence at the 0.9 percent labelling threshold would be achievable on a long-term basis. While co-existence is feasible, it is highly dependent on local environmental conditions and practices, such as the rate of adoption of GM varieties in a region and crop management. Various possibilities can be used in different situations and local operators should be able to choose the best solutions depending on local constraints. The validated biocontainment techniques may be an effective tool to dramatically reduce isolation distances as well.

Co-Existence in the supply chain: costs and methods of segregating GM and non-GM products

The concept of co-existence is directly related to segregation, which is the shape that the organisation of supply chains takes to make co-existence possible.

It costs to segregate GM and non-GM products. There are costs related to keeping the products separate from farm to factory, costs related to performing analytical tests which would reveal the need to label or not, and costs for maintaining product traceability.

Manufacturers today tend to work either exclusively with GM or non-GM raw materials or goods. GMO production is mostly limited to feed production. As animal-derived products are not labelled, co-existence is currently not an issue.

Co-existence in the supply chain is possible, however. Segregation of GM and non-GM supply chains is technically feasible, but the organisation of the chain, from the upstream farmers to the downstream stakeholders, plays a critical role in complying with the official labelling threshold of 0.9 percent.

From interviews conducted with stakeholders, it was found that the vast majority used a practical threshold lower than the official labelling threshold for quality or safety purposes. This was generally 0.1 percent of GMO content.

Models were developed by Co-Extra assessing the effect of variables on GM admixture in non-GM batches and the probability of these batches complying with a given threshold at each step of the supply chain.

The Co-Extra project also tracked the value of goods throughout selected supply chains and analysed and modelled supply chains to find the most cost-effective means of handling GM food and feed. The Co-Extra project identified hot spots in the chain where admixture can occur, such as in temporary silo storage, and practical measures were recommended for economic, reliable segregation. Data from the studies were integrated into an electronic Decision Support System (DSS) that can be used by GMO detection labs, inspectors, political decision-makers, farmers, importers and food processors for determining the practical and economic (cost/benefit) aspects of coexistence and traceability.

Producing non-GM food and feed is more costly. Depending on the commodity, additional costs can increase to 13 percent of total product turnover. These costs are related to the physical separation of GM and non-GM material along the supply chain from harvesting to manufacturing.

Production line strategies explored by the Co-Extra project included processing at two separate production sites; setting up two production lines in one location; and alternately processing GM and non-GM materials on one line, with or without prior cleaning of equipment and conveyor belts.

Co-existence within the same supply chain seems difficult to implement when GM pressure is high. It is only economically viable when there is a price differentiation between both products in the marketplace. Some stakeholders have stopped segregating GM and non-GM compound animal feed stocks because products derived from animals fed with GMOs are currently not labelled.

Co-Extra researchers also analysed consumer attitudes to GM labelling. In each country studied, at least 40 percent, and in some cases (such as in Germany and Denmark) 70 percent of the consumers wanted to be able to choose whether to buy and eat GM food. The more consumers exercise their freedom to choose, the greater the incentive for producers to offer products that do not need GM labelling.

GMO detection methods

The number of authorised GMOs is increasing rapidly worldwide. Since many of these GMOs are not authorised in the EU, it is necessary to discriminate analytically between authorised and unauthorised GMOs. Current detection technologies are often not only time-consuming but also are often applicable to only one or, at best, a few GMOs.

Proper product labelling as required by law depends on the reliable quantification of authorised GM content. However, the results of current detection methods display an uncertainty factor of 2. To demonstrate compliance with the labelling threshold of 0.9 %, this factor obliges analytical results actually to be less than 0.45 %.

To overcome such limitations, Co-Extra researchers have created innovative techniques and guidelines with the aim of developing more sensitive, validated, cost-effective, purpose-adapted methods for the detection and identification of both authorised and unauthorised GMOs, for example:

- A new method known as the 'matrix approach' was designed for routine sample screening. It tests simultaneously for the presence of a large number of possible DNA fragments and provides a list of GMOs that may be present. The results are then compared to a database of known GMOs and unusual combinations of DNA targets may indicate unknown GMOs. This approach may be extended with a screening microarray that permits the detection of several thousand genetic elements.

- New screening methods to improve GMO coverage in a given sample and thereby increasing the reliability of testing

- Multiplex GMO screening methods improve cost- and time-effectiveness of detection in a single step by addressing different GMOs that may be present in a sample. For example, the DualChip ® GMO micro-array is a method that uses multiplex PCR and subsequent hybridisation on a micro-array. Upon application of software using the ‘matrix approach’, the presence of unexpected GMOs may be indicated.

- Improvement of the performance of GMO detection was a central goal. For example, by combining a specific statistics-based technique with real-time PCR, the sensitivity of detection was improved as much as one hundredfold. Its application with new protocols for DNA extraction facilitates the efficient control of GMO presence in most processed soybean lecithins and oils.

- New on-site detection methods are among the most economical to date. Several such methods were developed in multiplex format and, for example, a duplex system for the detection and quantification of GT73 oilseed rape is ready for use by control laboratories.

- The detection and sampling work package also examined alternative amplification methods including non-PCR-based approaches. For example, loop-mediated isothermal amplification appeared promising as a component in broad use in GMO detection. In comparison to PCR, its advantages include decreased sensitivity to inhibitors and lower cost, while instruments for on-site detection already are available.

A validation process must demonstrate the reliability of a GMO detection method. Co-Extra further developed a new concept of validation. The ‘modular approach’, in which analytical methods are viewed as separate ‘modules’ that independently may be validated, is the most cost-effective validation process and is available for flexible implementation in routine laboratories.

Sampling

Representative samples are taken to the lab as a first step in testing for GMOs. Since unexpected GM content tends to be distributed unevenly, errors may result from improper sampling. In crop fields, grain shipments or flour containers, GMOs in any test lot usually are clustered in isolated hot-spots.

Optimised protocols that are standard throughout the EU would be the best way to address such challenges to sampling. Co-Extra researchers used statistical and software tools to design optimised sampling plans for seeds, grain, ingredients and end food products that maximise precision and certainty while minimising effort and cost.

Liability and Compensation

Provided co-existence regulations are followed with due care, damages should arise only in exceptional cases. Who is liable, though, if pollen flow or inadvertent admixtures of GMOs contaminate the harvest of conventional or organic farmers causing economic damage?

Such damage occurs when the proportion of GMOs in a product exceed the 0.9 percent threshold established by EU regulations making it then fall under mandatory labelling requirements which in turn cause the product to command a lower market price. How will non-GM farmers and producers be compensated?

The Co-Extra project looked into existing tort laws, insurance requirements, private sector compensation measures and state-supported compensation funds. It was found that current liability laws and redress schemes differ widely among the Member States and are often a reflection of the diverse attitudes of the Member States to GM farming.

Accordingly, Co-Extra is considering important:

- The coexistence strategies must from now on be thought of from the supply chain level and not only from field coexistence (present regulation).
- It is essential to insure a better distribution of supply chains' segregation costs by establishing a main principle; those introducing a new technology will take in charge the costs of segregation from the field to the consumer (Neighbourhood disturbances theory).
- It is important to quickly solve the question of various types of unknown or unauthorised events.
- Concerning seeds, it is important to quickly solve the matters of 1) the question of fortuitous present threshold 2) the one of the farmer's right to use « farm saved seeds »-but these seeds risk having an increasing level of unwanted GMOs in some species. 3) the question of the availability of conventional seeds which have been the object of a traditional technology of plant breeding to benefit from genetic progress.

Stakeholder opinions and attitudes on coexistence of GMOs with conventional and organic supply chains

Seven stakeholder workshops were organised by the Workpackage 'Dialogue and Communication' on the issue of co-existence in seven EU countries, and an online questionnaire was launched to survey the general attitudes and opinions towards co-existence. Among a broad spectrum of attitudes and information needs of stakeholders the following are the most dominant:

- There is an overwhelming wish to have the GM labelling thresholds for seeds regulated. This is over different countries and different stakeholders. Without these thresholds it is difficult to set practical co-existence measures.

- There is a general conviction and concern about the costs that co-existence regimes will entail in practice. Most stakeholders are of the opinion that co-existence measures will entail costs – as any regulation will entail costs – but there is difference of opinion on how significant these costs will be.
- There is a concern about the practicalities of sampling and testing strategies. Guidance may be necessary here, and perhaps also a discussion on whether testing is necessary in all situations, or that in many situations sampling will do, followed by testing if a problem has arisen.
- A common concern on how to deal with unauthorized events. Nobody would like to be confronted with an unauthorized event – especially one that is not authorized anywhere in the world – and there are questions on whether it is possible to prevent contamination with such events at all times.
- Especially from the side of the NGOs and organic farmers: a discussion on the legal meaning of the concepts of 'adventitious' and 'technically unavoidable'. There is general recognition of the fact that the 0.9% is a labelling threshold. But there is difference of opinion on what the consequences of these concepts are for the design of co-existence measures. What should practical co-existence measures be aiming at?
- Most stakeholders are not supporters of a hybrid regulatory model with coexistence rules both on the European and the country level, but some may stress the need for flexibility, especially on the practical level.
- Many stakeholders recommend to monitoring the development of practical co-existence measures and compensation schemes in the different EU member states, with an eye on harmonization and the prevention of competitive advantages and disadvantages for particular farmers.
- Farmers are inclined to see co-existence regulatory frameworks as yet another set of requirements that will increase the amount of paperwork that they have to do. They are not in favour of having to be certified or licensed to be able to grow GM crops.
- The questionnaire also shows that although co-existence is an economic and choice issue, some stakeholders perceive, present or use it as an environmental or social issue, especially those stakeholders having a more negative opinion about GMOs.

Co-Extra data integration

Numerous data are issued from Co-Extra work and thus can only with difficulty be made available to the stakeholders, or the control routine laboratories. Accordingly a large part of the Co-Extra work was dedicated to the integration of data into a tool rather more easily usable by stakeholders. This work was focused onto a quite user-friendly "Decision Support System" (DSS)

The outcomes of Co-Extra provide a whole range of stakeholders: farmers, EU policy makers, importers, transporters, feed/food producers, retailers, consumers, analytical laboratories, users of test reports from analytical laboratories, operators and managers of official control with science-based, ready to use information.

The DSS provides data and advice for various decision questions that occur in supply chains involving GMOs, for instance:

- Will my (intermediary) product, given a current set of used procedures and materials, contain GMOs below a specified threshold level?
- Is there any possibility that my (intermediary) product contains unapproved GMOs?
- Which methods perform best or can be used at all for a given analytical or sampling purpose?
- What are the costs associated with maintaining GMO content below some specified threshold?

Currently, there are six models implemented or under development:

- *Analytical Model*: aimed at the assessment of analytical methods, including DNA extraction and DNA analysis methods;
- *Sampling Model*: assessment of sampling plans;
- *Unapproved GM Model*: assessing the risk of contamination with unauthorized GMO varieties based on traceability data about the product (for instance, type of product, country of origin, type and mode of transportation);
- *Transportation Model*: assessment of potential GM presence due to transportation based on product traceability data;
- *Dryer and Starch Models*: assessing the effect of control parameters (such as using different strategies for handling GM and non-GM batches) to the collection and processing of maize.

All together these modules are currently pre-validated by Co-Extra partners. A second step of validation should be started as soon as possible with ENGL members and some stakeholders before any release.

More information:

- Presentations at Co-Extra's Final Conference
- A more comprehensive summary of results by Co-Extra's coordinator Yves Bertheau
- Scientific deliverables of Co-Extra
- Scientific publications of Co-Extra

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