ASIRPA

Socio-economic analysis of the diversity of
Impacts of Public Research for Agriculture

Safety analysis and decision-making tools for the food-packaging sector

Executive Summary

September 2013

(Revised July 2014)

I. Maillet

A. Gaunand

L. Colinet

Context

Food packaging maintains the benefits of food processing after the process is complete, enabling foods to travel safely for long distances from their point of origin and still be wholesome at the time of consumption. Both retort packaging (e.g. flexible food pouches) and aseptic packaging (e.g. Tetrapak fluid containers) have made major contributions to the packaging field, either allowing food to be prepared, cooked and sterilized within the package (i.e. retort packaging), or allowing the food to be treated in a more minimal way, thus maintaining greater nutritional value while ensuring food sterility. Notably, food shelf life has been extended and food waste reduced, thus improving the overall food supply chain. In short, thanks to a steady flow of innovations in various fields – polymer and material sciences (barrier polymers or multilayer assemblies, active systems…), filling, sealing and printing technologies – food packaging systems have been progressively adapted to Man's evolving lifestyle (e.g. portioning, snacking, ready-to-eat meals, oven heatable systems, easy-opening, light and disposable systems etc). Nevertheless, this progress has also created a certain number of new concerns that are linked to different parts of the food value chain. Packaging intensifies the use of energy and materials, and provokes new challenges in terms of environmental protection, linked to the end of life of packaging materials. Moreover, the actual use of food packaging and the multitude and complexity of currently available packaging materials also generates health concerns linked to the undesirable interactions of packaging components with the food. This last point is exemplified by recent concerns linked to the widespread use in food packaging of compounds such as bisphenol A, 4 methyl-benzophenone, or isopropyl thioxanthone. Taking into account these concerns, which readily undermine consumer confidence and regularly alert regulatory authorities, the food industry is constantly looking for improved packaging that both ensures the optimal handling, freshness and nutritional value of food, while complying with European standards, preferably anticipating evolutions of these. This is a challenge because food packaging companies are often SME's that have limited technical/ in-depth knowledge of their packaging materials. Therefore, it is important that organizations such as INRA treat the subject of food packaging and provide assistance to industrial players.

In the last fifteen years, INRA has worked both on the development of new packaging systems and the evaluation of risks linked to food packaging, and has contributed at the European level (EFSA) to develop policy. In order to develop new decision-making tools, INRA scientists have gathered information and compiled databases that deal with gas permeation and compound migration issues in packaging. These tools assist in packaging design and packaging quality control, and thus provide industrial players with increased ability to assess packaging and achieve compliance with regulations.

The regulatory context

The authorization of substances is divided into a risk assessment procedure and a risk management decision. Risk evaluation includes 4 steps: the identification of hazards, the definition of dose-response relationships, the evaluation of human exposure, and on the basis of the three preceding steps, the characterisation of health risks.

- **The system of risk evaluation: an international network**

In France, the responsibility for the evaluation of health risks mainly rests with the national agency responsible for the protection of food safety, the environment, and labour (ANSES). Typically the evaluation process calls upon independent scientific expertise, and is carried out by agency working groups, on the basis of which the agency formulates a notice, which is sent to policymakers. Risk management and, notably, the consideration of concerns other than those that are health-related (economic, social, political) is undertaken by the Directorate General for Health. It is also noteworthy, that INSERM is the usual source of expertise for the health ministry and ANSES, being regularly called upon to prepare assessment reports.

At the European scale, the counterpart of ANSES is the European Food Safety Authority (EFSA), which was created in January 2002, following a series of food crises (e.g., BSE, dioxins) in Europe in the late 1990s. Established by the European Parliament and Council Regulation (EC), which laid down the basic

principles and requirements for food legislation, EFSA is an independent source of scientific advice and communication on risks associated with the food chain. EFSA's remit covers food and feed safety, nutrition, animal health and welfare, plant protection, and plant health. A key element in the EFSA's mandate is to communicate on risks associated with the food chain. EFSA also has an important role in collecting and analyzing scientific data to ensure the European risk assessment is supported by the most complete scientific information available.

EFSA provides independent scientific advice through its Scientific Committee (SC), 10 Scientific Panels, and 6 Supporting Units. One of the tasks of the Scientific Committee for Food (SCF) is to advise the Commission on European Communities (CEC) on the safety-in-use of monomers, other starting substances and additives used in food packaging materials. This advice forms the basis of Community Directives that provide regulation of food packaging materials, using lists of authorized substances.

In 2008, the panel on food additives, flavourings, processing aids and materials in contact with food (AFC) was replaced by a new panel on food additives and nutrient sources added to food (ANS) and another panel on food contact materials, enzymes, flavourings and processing aids (CEF). Both of these panels deal with questions related to safety. Accordingly, the ANS panels treats issues related to the use of food additives, nutrient sources and other substances that are deliberately added to food, excluding flavourings and enzymes, while the CEF panel examines the use of materials in contact with food, enzymes, flavourings and processing aids, and also with questions related to the safety of processes.

- **Risk management**

Risk management is distinct from risk assessment. Risk management involves weighting the different possible options, in consultation with all stakeholders, taking into account risk assessment and any other factors that might affect consumer safety. Risk management also promotes good commercial practices and identifies appropriate prevention measures and control procedures. In France, the government administration, "Direction Générale de la Concurrence, de la Consommation et de la Répression des Fraudes" (DGCCRF), is charged with the responsibility of preparing legislation or, increasingly, of transposing European legislation to national level. Accordingly, the DGCCRF defines or improves security legislation related to food and industrial products. At the European level, the Commission's Department of Health and Consumers (DG-SANCO) is responsible for the implementation of European Union laws on the safety of food and other products, on consumers' rights and on the protection of people's health (Figure 1).

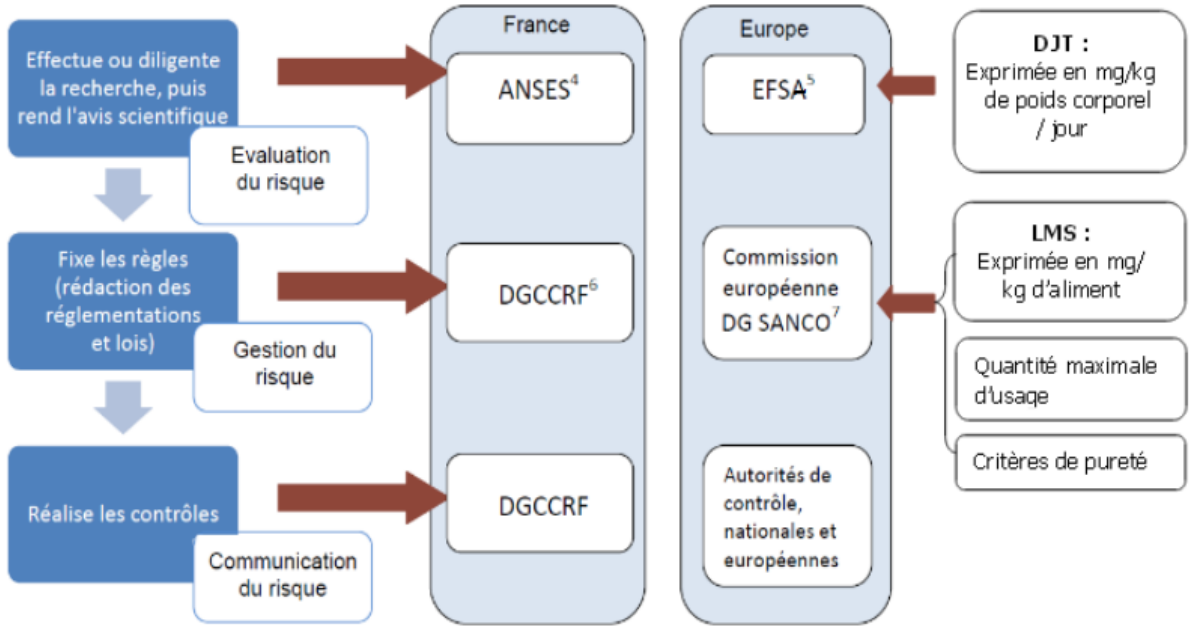


Figure 1: Role of French and European institutions involved in sanitary risk assessment and management

- **Laws, directives and regulations**

Various regulations and norms relative to food packaging exist. An overview is provided in figure 2. The aim is to limit the consumer's exposure to food packaging substances. The basis of the regulation is laid out in article 3 of regulation N° EC 1935/2004: "The principle underlying this regulation is that any material or article intended to come into contact directly or indirectly with food must be sufficiently inert to preclude substances from being transferred to food in quantities large enough to endanger human health or to bring about an unacceptable change in the composition of the food or a deterioration in its organoleptic properties."

a) b)

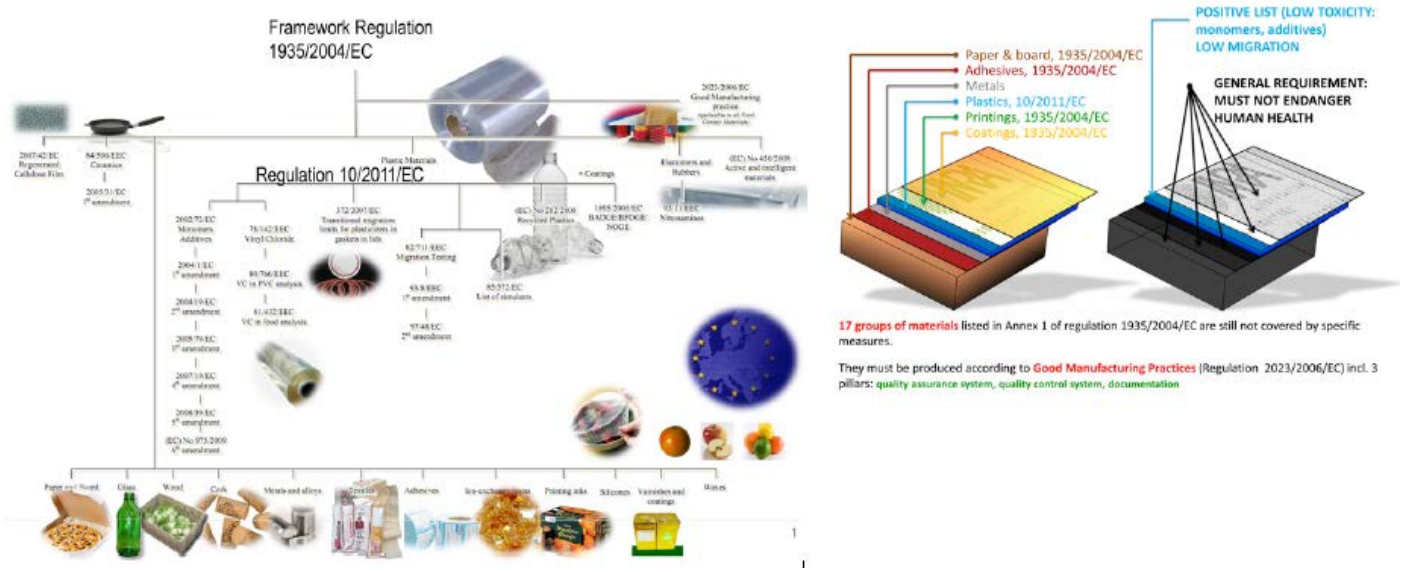


Figure2. Overview of EU regulation of food contact materials: a) tree of regulations, b) limitations

Thermoplastic materials that are likely to come into contact with food, are regulated by a European directive that defines a list of permitted substances, which are judged safe on the basis of their known toxicity and ability to migrate in packaging. The European synopsis of permitted substances currently contains 2,700 entries (CE, 2005), of which approximately 400 are subject to certain restrictions with regard to specific uses. These restrictions, known as migration specific limits (LMS), either fixes a maximum amount of substance that can desorb into food per unit of packaging surface area, or simply a maximum concentration of substance allowed within the packaging material. Recent evolution of European regulations reveals a tendency to partially substitute expensive experimental identification and quantification of controlled packaging substances by predictive modeling, which simulates substance migration in packaging and provides indications concerning the conformity of given materials (directive 72/2002/EC). Similarly, risk management linked to the commercial deployment of new substances (in the framework of the directive 1935/2004/EC), increasingly uses predictive models.

Unlike plastics, sixteen other groups of materials (inks, adhesives, papers etc) used in packaging are not yet covered by a specific regulation. Nevertheless, these materials must be manufactured using good practices, according to the regulation 2023/2006/EC. Presently, these good practices are defined by the professionals themselves. The underlying basis of these is ill-defined (the use of low toxicity compounds is recommended, but maximal concentrations of substances are not fixed) and the recommendations are not binding. Similarly, an increasing tendency to use recycled materials or intelligent packaging is a source of new risks for consumers that requires new regulations and monitoring.

<u>Today's scientific challenges</u>

The increasing use of plastics (present in 70% of food packaging) and composite packaging (e.g. multi-layers, recycled materials etc) is mechanically increasing the need for a better control of the nature and quantity of packaging-derived substances that are ingested by the consumer.

Safety of food, in general, and of packaging materials, in particular, rests on three pillars: toxicity of a substance, level of migration of the substance into a food, and level of exposure to that food. Toxicity is usually defined by standard tests that establish an acceptable or tolerable level of daily exposure. However, establishing the level of exposure is complex and full of uncertainties. To determine exposure, it is necessary to understand and measure migration of substances into food, and quantify the consumption of the food. However, migration itself is a complex phenomenon, because it strongly depends on the nature of the food matrix. The term 'migration' includes two phenomena (partition and diffusion), both of which are important for the determination of the actual concentration of contaminants in a food system at a given time. Accordingly, substances that compose packaging thermoplastics (e.g. additives, manufacturing residues, polymer precursors, polymerization side-products etc) can sometimes readily migrate into food systems, with the principal migrants being low molecular mass compounds.

As previously explained, a positive list of substances and their restrictions with regard to specific uses is permitted by EU regulations. However, materials and substances that are not specifically mentioned in European directives are the principal causes of sanitary crises. Since it is not practically feasible to perform in-depth analyses of all of the substances, predictive approaches might provide an alternative strategy to avoid extensive testing, even though these methods will still require knowledge of the physico-chemical properties of a wide range of substances.

The position of plastics formulators in the industrial value chain

Lobbying in Europe is mainly performed by the chemicals and plastics industries and their representatives (European Council of the Chemical Industry and Plastic-Europe). Therefore, the packaging formulators, which are often SMEs, are confronted with the difficult fact that they are legally responsible for the safety of food packaging, while being rather impotent. This is problematic and puts the food processors in a delicate situation, on one hand having to satisfy the demands of both the consumer (e.g. practical packaging) and the food industrial processor, and on the other hand demands having to accept whatever is proposed by the petrochemical and plastics industry. The relative impotency of the plastics formulators lies not only with the fact that their upstream suppliers are powerful, but also that they are often located abroad. China and India are major suppliers of raw materials for plastics (i.e. building block chemicals), while the plastics formulators, who deal with a whole range of industrial sectors and not just food packaging, are equally spread out between Asia (without Japan), Europe and North America.

The French plastic industry (producers of plastic materials and processors) comprises 4,040 companies (majority small- and medium-sized businesses in the processing sector), who employ 143,630 workers and realise gross revenues of €38.2B. The small size of the companies limits research that can be conducted on plastics composition and formulation, which justifies the development of a public freely-accessible platform.

Therefore, it is true to summarize that today's packaging formulation sector is highly dispersed (cf. the industry representative's report 2009) and in a weak position regarding its suppliers, highly dependent on its food industry customer and rather impotent with regard to its role as the guarantor of food packaging safety. One example of this industry's current difficulties is the ongoing debate about bisphenol A.

Inputs and productive configuration

Research aims

Since the French National Institute for Agricultural Research (INRA) plays a leading role in the EU in the field of mathematical modeling for the packaging community, the initial intent was to accelerate the diffusion of in-house methodologies by providing ready to use codes, mostly via web-oriented tools, and to integrate them within a single portal. INRA aimed at developing basic scientific and engineering tools for the reliable implementation of migration modeling for the packaging community (packaging and food industries, control and regulatory authorities, food safety agencies). As the approach was based on chemical engineering concepts, underpinning research was required to pioneer predictive techniques.

In particular, three fields were investigated:

- molecular mechanisms involved in the control of transport coefficients (partition, diffusion coefficients) and in their activation with temperature and plasticizing effects;
- exact mathematical solutions of transport equations for punctual and probabilistic assessment of the contamination of food products by packaging materials;
- design of decision tools, which act as expert systems that can handle incomplete or less accurate data sets (molecular properties and parameters).

Resources and skills mobilized by INRA

For more than 15 years, INRA, and in particular two joint research units of the CEPIA division, have worked on security and quality of food contact materials. Some years ago, a team led by Dr Alexandre Feigenbaum (who since became director of the EFSA's Ingredients and Packaging unit) and based in UMR FARE, an INRA - Reims Champagne-Ardenne University laboratory in Reims, studied transfer phenomena in materials and applied its know-how to the safety of packed food. Following the departure of A. Feigenbaum from INRA and the transfer of a scientist (Dr Olivier Vitrac) from UMR FARE to UMR IPA in Massy (now called UMR GENIAL), work was begun on the probabilistic modeling of migration in packaging, and on the development of decision making methods (molecular modeling, numerical identification of transport properties).

Network of actors involved

INRA's knowledge in the field of safety of materials that come into contact with food has been reinforced by its participation in many EU--funded projects (e.g. AIR2-CT93-1014 "Recycled and Reused Plastics", CT 94-1025 "Safety and Quality of Plastics Materials", FAIR-CT98-4318 "Recyclability", COLL-CT-030309 FP6 Migresives "migration from adhesives", JRC TF-MATHMOD 2003 "Mathematical Modelling of Migration") and through its contribution to various studies for the EU-Commission (for instance SMT-CT98-7513 "Evaluation of migration models linked to Directive 90/128/EEC"). The prominent collaborative projects and networks funded by the EU (either by DG-Research or DG-SANCO) were mainly "mainstream" research and oriented towards support of regulation. In particular, the European projects provided the means to collect reference data (e.g. physico-chemical properties, migration data), but actually had little impact on the understanding of the underlying molecular mechanisms that are responsible for the contamination of food products by substances originating from packaging materials. These data have since been collected and added to the database present at the INRA Safe Food Pack Portal (SFPP).

In France, INRA has forged a tight partnership with a technical center LNE ("Laboratoire National de métrologie et d'Essais") from ACTIA, collaborating with this center in the French research program, ACTIA RA05.22 "Decision tools for compliance testing of food contact materials". This project was focused on the identification of the main limitations that hamper the dissemination to food industry testing laboratories of fast techniques, previously developed within EU projects, for compliance testing. This collaboration has been pursued in the framework of the joint technology network (RMT) ProPackFood and within the project "SafeFoodPack Design (SFPD)", developed in the framework of ANR's National Program on Food and food industry ("ALimentation et Industries Alimentaires", ALIA) (2011-2013). The SAFEFOODPACK DESIGN project (Computer-aided design of safe food plastic packaging) aimed to develop a computer-aided solution for the design of barrier and safe food packaging systems. This last project, which is still on-going, provides the means to continuously improve the SFPP portal (see research outputs).

Research outputs

A breakthrough in research

INRA's work has addressed the main causes of food contamination by packaging substances, namely the migration of non-covalently bonded substances from materials to packaged food and the possible reactions between food components and those present in packaging. This research has been carried out at different scales, from the molecular level up to the packaging and food life cycles, including recycling and renewable resources issues. The knowledge that has been gained is generic and can be used in various contexts to assess consumer exposure, to identify appropriate corrective actions to be used either by the chemical industry (producers of packaging precursors), the intermediate processors or the

food industry. Finally, the developed approaches and tools can be used to orientate food controls, to enforce or devise new regulations and to perform rapid sanitary surveys. After several decades of work and development, most of the knowledge has been transferred and integrated into several flexible physical, chemical, and mathematical models, which have found also applications in the neighboring fields of polymer/material engineering.

More precisely, molecular mechanisms involved in the control of transport coefficients (partition coefficients, diffusion coefficients) and in their activation with temperature and plasticizing effects have been investigated, especially for plastic materials. Molecular modeling strategies and theories have been developed and validated to calculate brute force diffusion and partition coefficients, and associated temperature-dependent effects. The concepts of stochastic resolution of diffusion equations to capture variability and uncertainty effects on final food contamination have also been developed. The current database includes 1,100 diffusion coefficients, 80 activation energies and about 120 partition coefficients. It is hosted by INRA with the support of the Joint Research Centre (European Commission, Ispra, Italy).

SafeFood Packing Portal (SFPP), an open-source, client-server platform, online since 2006

The outputs of both the SFPD project and previous projects to which INRA has participated, have been integrated into an open-source client-server platform, called the SafeFood Packing Portal (SFPP), which is a website (http://modmol.agroparistech.fr/) dedicated to the safety of food contact materials. Since the portal relies exclusively on open standards, it is possible to integrate it seamlessly within existing tools used by industry and laboratories, and to share common data formats between stakeholders. Today, this website, which was made supported by the national thematic network PROPACKFOOD, is an emblematic achievement within the French food packaging sector.

The portal is used to:
- predict toxicity of food packaging, to run verifications, to comply with the EU plastics directive 2002/72/EC and regulation 2004/1935//EC;
- assess the contamination level of packaged food available on the market (risk assessment); to contribute to the evaluation of the consumer exposure to substances originating from plastic materials, limit toxicity of food packaging by supporting the design optimization of safe packaging materials for food contact (with reduced migration).

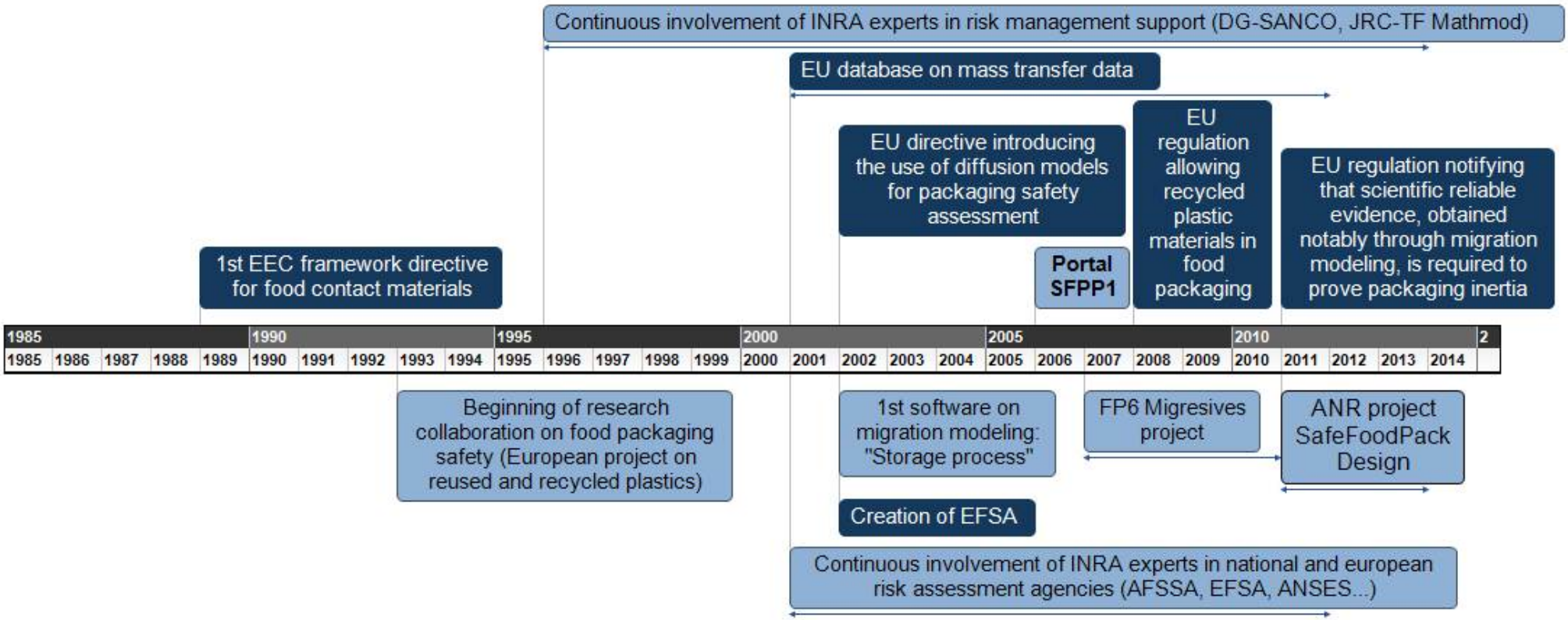
UMR GENIAL (previously IPA) has developed all versions of SFPP, with version 3.0 of SFPP being currently available.

SFPP compiles decision-making tools for the food and packaging community

The portal compiles the latest developments in terms of decision support tools, based on numerical simulation and databases for the food and packaging community, including:

- Databases (formulation rule bases, physico-chemical data). Migration data are prerequisites to extend the validation of diffusion models and to predict the migration of chemicals resulting from contact with food. Most of the data have been collected during the SMT-CT98-7573 project, funded by EU/DG-SANCO. Additional data were collected internally by IVV (Franufofer, Freising, Germany), Fabes Forshung Gmbh (Munich, Germany), TNO (Netherlands) and Coca-Cola (Atlanta, USA). Data from INRA has also been included in the database. It is currently the largest packaging-related database available in the world.
- Simulation tools to optimize barrier properties and minimize the risk of migration during specific conditions of use. The software “Monolayer” is exemplary of the simulation tools that have been made available. This software solves mass transfer problems between monolayer materials and food. Other available software are “Multilayer”, for the simulation of multi-layer materials, and “Exporisk”, which estimates consumer exposure taking into account all packaging materials that are used by a single consumer, one household or a target population.
- Safe design methodologies,
- Traceability management tools.

Chronology



Legend: Events directly involving INRA | Contextual events

Knowledge flow and intermediaries

Worldwide dissemination of INRA's decision-making tools:

The SFPP was conceived to maximize dissemination of migration assessment methodologies. Likewise, the following features characterize this portal:

- user interfaces are written in HTML/Javascript/CSS,
- no installation and computer specifications are required, as INRA owned computational resources are used,
- the computational engines are those used by INRA for research purposes (low bug rate),
- all the tools can be integrated into a common and comprehensive "eco-system", which is comprised of databases, training lectures, manuals and interactive applets,
- updates and maintenance is easy.

Figure 3 shows the world locations at which the SFPP portal was accessed during a 3-month period in 2013. During this time, 1252 different users connected to SFPP. Connections are anonymous, so the details of the professional status of the people cannot be determined. However, it is known that CTCPA (French Technical Center for Product Conservation), ANSES (the French Agency for risk assessment), EFSA, FDA (Food and Drug Administration), as well as ANIA (Spain) and the Fraunhofer Institutes, are using INRA's decision-making tools.

Figure 3: Sites connected to SFPP during the period 14th May to 13th August, 2013.

In order to better penetrate the industrial sector, tools available via SFPP have been developed under a strict open-source license (CECILL B license compatible GPL2 and Berkley license). Expert systems and corresponding databases are also under CECILL license. Therefore, while using their proprietary codes, companies can reuse parts of the algorithms or link their own tools to INRA computational engines. In this way, the SFPP-available tools can be used to devise commercial tools. Support to such deployment is provided by professional associations (Feica) and technical centers (LNE, CASIMIR, CTCPA in France).

INRA's contributions to risk assessment and risk management EFA/EFSA risk assessment

In recognition of his expertise in the food packaging area, Dr A. Feigenbaum from INRA CEPIA (UMR FARE), was designated chairperson of the AFSSA scientific panel on Food contact materials (MCDA Committee) in 2002. In 2007, he joined EFSA, and until 2013 he successively worked on and chaired different expert panels focused on materials in contact with food (AFC, CEF) and packaging (FIP).

DG-SANCO: risk management

Dr O. Vitrac (UMR GENIAL) participated as an academic expert to the EU legislation currently in force (Directive 2002/72/EC, Regulation 1935/2004/EC). The Directive introduces the possibility to demonstrate the conformity of plastic material by calculation, using migration modeling. Afterwards, Dr. Vitrac also provided scientific and technical advice in order to ensure that the Directive 2002/72/EC can be understood and applied by end users. He took part in a DG-SANCO task force (JRC TH MATMOD) that published a manual for end users that describes the prediction model and how it can be used to predict migration values for compliance purposes (EUR 24514 EN 2010).

Through his involvement in DG-SANCO's actions, Dr O. Vitrac has familiarized members of DG-SANCO personnel with the basics of migration modeling.

Training and coordination of intermediaries and other actors

Since training is a good vector to disseminate prediction and decision-making tools, training has also been offered to a variety of stakeholder groups. In this respect, INRA has played an active role (in collaboration with the Joint Research Centre, Ispra, Italy or with EU professional associations such as FEICA) in the training of both future trainers and end-users of EU regulations. In France, training has been given to industrial stakeholders, technical centers, national reference laboratories, universities and in engineering schools. One specific example of such training is the teaching proffered by INRA to the staff of the technical center, LNE, which is INRA's principal partner in the field. INRA continues to offer advice and assistance to LNE, for instance to elaborate functional specifications to design food packaging.

Impacts 1

INRA's activities in the food packaging field has produced several impacts (mainly political and sanitary), which are closely related to the food regulation and safety domains.

Alternatives:

Developing a portal such as the Safe Food Packaging Portal required specific numeric implementations, because of the great variety of combined techniques and the need for reliable and computationally-effective methods. To date, there is no known commercially-available alternative software, because commercial products (e.g. MIGRATEST EXP from FABES, http://www.fabes-online.de/kontakt.php?lang=en&mode=ansprechpartner, or AKTS-SML, http://www.akts.com/sml-diffusion-migration-multilayer-packaging/download-diffusion-prediction-software.html) usually rely on a single technique, and do not provide source code access with sufficient programming interfaces.

Political Impact:

The elaboration of an exhaustive database containing transport coefficients (partition and diffusion coefficient), and models of substances' migration and their incorporation in open-source software further made available on a unique SFPP portal have deeply contributed to the policy-making on food packaging at the European level: it supported the formulation of regulations and empowered its implementation.

- **Impact on the formulation of various EU regulation, among which the 10/2011/EC regulation:**

In the academic sphere, INRA and its collaborators from the Central Science Laboratory/FERA (UK) and the Fraunhofer Institute (Germany) have represented and defended public interests within the food contact material regulatory commission of the Health and Consumer Protection Directorate. They have provided basic scientific support to successive EU texts (2002/72/EC, 10/2011/EC…) by drafting EU Directives / regulations or related guidance documents, and suggested modifications or revisions of

existing regulation to account for new food simulants, new calculation methods, new data etc or to accommodate new trends (e.g. recycled materials: polyethylene terephthalate or currently polyolefins; active packaging). Thus, along with other actors, INRA has contributed to the promotion of diffusion modeling as a recognized methodology to assess food safety and ensure compliance.

The 10/2011/EC regulation enforces the migration potential calculation and modeling as a standard to assess food safety: "To screen for specific migration, the migration potential can be calculated based on the residual content of the substance in the material or article applying generally recognized diffusion models based on scientific evidence that are constructed such as to overestimate real migration".

This regulation also mobilizes a special task force (TGF MathMod) in charge of validating acceptable models for EU members (models from SFPP portal are registered in the list).

- **Impact on the enforcement of EU regulations:**

The INRA-based SFPP portal enables the plastic industry to assess and prove the safety compliance of their food packaging using predictive approach modeling, which is cheaper and easier than migration testing. The 10/2011/EC regulation recognizes the modeling tests as an official demonstration of compliance: "Such demonstration of compliance may be based on migration testing. As migration testing is complex, costly and time consuming it should be admissible that compliance can be demonstrated also by calculations, including modeling, other analysis, and scientific evidence or reasoning if these render results which are at least as severe as the migration testing."

Since models are now widely used in certification request submissions, the EFSA has become proficient in the assessment of the results provided by modeling. To achieve this, training has been provided to the EFSA who are responsible for controlling and judging substance compliance. Training to new EU member states is also provided by the Joint Research Center, based in Italy.

Finally, the developed approaches and tools can be used to orient food controls.

Sanitary impact:

The developed tool is now able to take into consideration a number of troublesome molecules that previously escaped regulation. The developed approach can be used to perform rapid sanitary surveys. The importance of this can be illustrated by a photoinitiator that was used in inks that printed onto liquid milk cartons. The related health crisis would probably have been avoided if this molecule had been analyzed using INRA's evaluation tools.

Economic impact:

The decision making tool provided by SFPP is used for safety compliance and therefore prevents the occurrence of sanitary crises and avoids economically-harmful distrust of consumers towards the packaging and food industries.

Impacts 2

Use of the decision making tools in support to the development of a new recycling industry

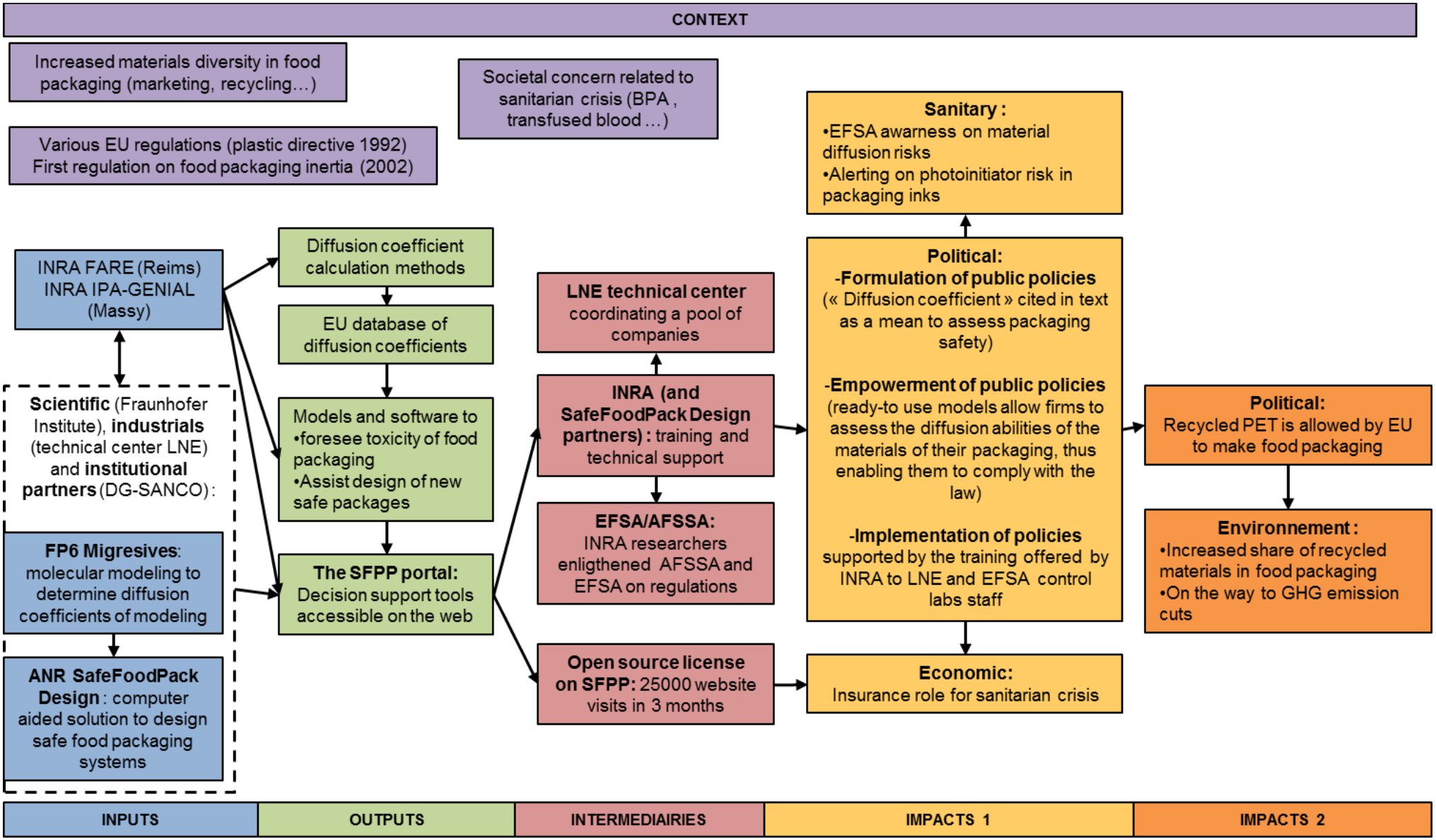
Along with its scientific partners and based on the use of predictive models in public decision, INRA also suggested regulations to accommodate new trends recycled materials (polyethylene terephthalate or currently polyolefins for active packaging). Thus the recycled polyethylene terephthalate (PET) was authorized for food contact (Commission regulation EC No 282/2008). The underlying principle of the evaluations made by AFSSA and EFSA is to apply the cleaning efficiency of a recycling technology or process to a reference contamination level for post consumer PET. Furthermore, the proportion of PET from non-food consumer applications should be no more than 5% in the input to be recycled.

It is noteworthy that because of the EU legislation, a new recycling industry has emerged. This emerging industry has potential economic and environmental impacts. Automatized processes for waste sorting and recycling, and the growing consumer demand for the use of recycled materials in plastic bottles, means that Europe is now recycling most of the bottles it uses. Likewise, local recycling is

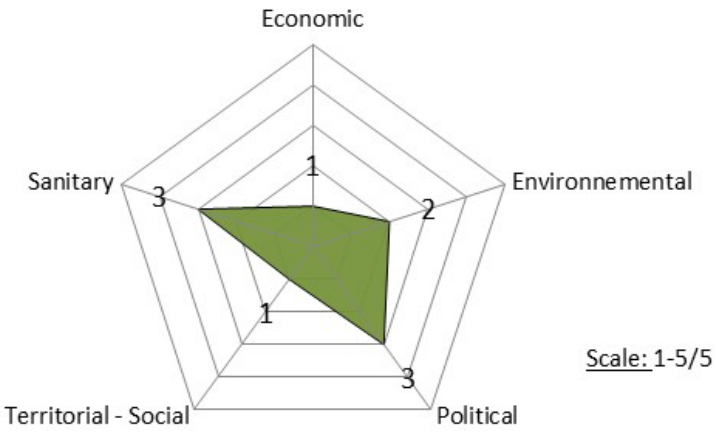
increasingly favored.

In the food industry, the incorporation of more and more recycled materials in packaging contributes is helping to reduce GHG emissions, since 1 ton of recycled PET leads to a GHG (eq. CO_2) reduction of 2.5 tons. For a bottle of 1.5 liter, CO_2 emissions are reduced by 11 % across the whole chain. Therefore, for industry such a strategy helps to improve their image and their environmental performance.

Impact Pathway



Vector of impact



Dimension of impact	Importance (/5)	
Political	**3/5**	**Use in public policy**: SFPP supported the formulation of regulations and empowered its implementation. Contribution, along with other actors, to the formulation of new EU regulations making a standard out of the *diffusion coefficients* use to assess packaging safety. Empowerment of public policies: diffusion models are strongly recommended to prove inertia of materials. **Contribution to the implementation of policy**: tools available for the private sector (SME's through technical center) and the regulatory bodies. Regulation on recycled PET use on food packaging. **Low mobilization in the general public debate.** But high media coverage of assessment methods in professional arena. No agenda setting but the political agenda gives an opportunity for research to grow. **Stakes of related policies** may be serious
Environmental	**2/5**	Use of recycled PET in industries: GHG emission decrease.
Sanitary	**3/5**	Packaging materials that were not tested and were the source of recent crises are now tested. Could have prevented crisis on photoinitiator risk in packaging inks
Economic	**1/5,** potentially higher	Insurance role against economic losses related to potential sanitarian crisis

Data sources

- Feigenbaum, A., P. Dole, S. Aucejo, D. Dainelli, C. D. C. Garcia, T. Hankemeier, Y. N'Gono, C. D. Papaspyrides, P. Paseiro, S. Pastorelli, S. Pavlidou, P. Y. Pennarun, P. Saillard, L. Vidal, O. Vitrac and Y. Voulzatis (2005). "Functional barriers: Properties and evaluation." Food Additives and Contaminants 22(10):956-967.
- Gillet, G., O. Vitrac, D. Tissier, P. Saillard and S. Desobry (2009). "Development of decision tools to assess migration from plastic materials in contact with food." Food Additives and Contaminants Part a-Chemistry Analysis Control Exposure & Risk Assessment 26(12): 1556-1573.
- Gontard, N. (2000). Les emballages actifs. tec et Doc / Lavoisier, 264p.
- Vitrac, O., J. Lezervant and A. Feigenbaum (2006). "Decision trees as applied to the robust estimation of diffusion coefficients in polyolefins." Journal of Applied Polymer Science 101(4):2167-2186.
- Vitrac, O., A. Mougharbel and A. Feigenbaum (2007). "Interfacial mass transport properties which control the migration of packaging constituents into foodstuffs." Journal of Food Engineering 79(3): 1048-1064.