



European
Commission

Science for Food

JRC thematic report

Joint
Research
Centre (JRC)

*The European Commission's
in-house science service*

If you would like to learn more about the activities of the JRC, please contact:

Geraldine Barry
European Commission
Joint Research Centre
Communication Unit
Head of Unit

CDMA 04/168
1050 Brussels
Belgium

Brussels
Tel. +32 (0)2 29 74181
Fax +32 (0)2 29 85523

Ispra
Tel. +39 0332 78 9889
Fax +39 0332 78 5409

Contact: <https://ec.europa.eu/jrc/en/contact>
Website: <https://ec.europa.eu/jrc/>

European Commission
Joint Research Centre

Legal Notice

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of this publication.

Reproduction is authorised provided the source is acknowledged.

A great deal of additional information on the European Union is available on the internet. It can be accessed through the Europa server (<http://europa.eu/>)

JRC 90423
EUR 27187 EN

ISBN 978-92-79-46015-9 (pdf)
ISBN 978-92-79-46013-5 (print)
ISSN 1831-9424 (online)
ISSN 1018-5593 (print)
doi: 10.2760/603998 (pdf)

Luxembourg: Publications Office of the European Union, 2015

© European Union, 2015

Printed in Belgium

Contents

Foreword by Vladimír Šucha, JRC Director-General	2
Introduction	4
1. Science underpinning EU food policy	6
1.1. The European food-testing infrastructure: EU reference laboratories managed by the Joint Research Centre	6
1.2. Monitoring radionuclides in the environment and food	12
1.3. Food allergens: validating testing procedures to detect allergens and gluten in food	13
1.4. Gluten intolerance	13
2. Acting today for a better tomorrow: global food security	14
2.1. Monitoring agricultural resources for food security	14
2.2. Scientific tools and methods for food security	15
2.3. Food market developments and uncertainty	17
2.4. Nutrition security and resilience	18
2.5. Outlook for fisheries and aquaculture	18
2.6. JRC's food security foresight for 2030	20
3. Research in agriculture: outlook for our food and land	21
3.1. Modelling support for the Common Agricultural Policy	21
3.2. Agricultural monitoring and forecasting	22
3.3. Support to CAP implementation	22
3.4. Indirect Land Use Change (ILUC)	23
3.5. Soil data and soil resources	23
3.6. Promoting environmental sustainability in the food supply chain	24
4. Food authenticity and quality	25
4.1. Food labelling: the right of consumers to be informed	25
4.2. Food authenticity	25
4.3. Science in support of customs tariff classification and excise duties	27
4.4. Coexistence of genetically modified and non-GM crops	27
5. Food for health	28
5.1. Nutrition, informed food choices and disease prevention	28
5.2. Healthy diets	29
6. Fostering the technological innovation flow	30
6.1. New plant breeding techniques (NPBTs)	30
6.2. Genetics and genomics in support of sustainable and efficient aquaculture	30
6.3. Next generation sequencing technologies for identifying food constituents	31
6.4. Nanomaterials	32
Acronyms	33
Useful tools	34
Publications	35
Partners	40



Foreword by Vladimír Šucha, JRC Director-General



Access to safe, healthy and nutritious food is essential to preserve life and promote good health. In Europe, around 500 million consumers expect to have access to safe and nutritious food every day. EU food safety policy safeguards health along the agri-food chain. A body of law underpinned by solid science and risk assessment marks the

cornerstone of our “from farm to fork” policy. As a result, Europeans can enjoy safe and nutritious food produced from healthy plants and animals, whilst enabling the food industry - Europe’s largest manufacturing and employment sector - to operate under the best possible conditions.

Food safety requirements go hand in hand with public

health and economic requirements. Promoting food safety together with healthy and sustainable diets can contribute to a healthier population as well as an appreciable food waste reduction. If we take into consideration the increasing environmental concerns, growing competition for land use and our changing dietary patterns, we realise the lack of sustainability in our current food system.

We often take food for granted, but at a global scale, with an ever growing global population, guaranteeing its availability has taken on a pressing dimension. Over 800 million people face hunger worldwide and the demand for food is expected to grow by 60% by 2050, making food security one of the biggest global challenges. This contrasts with the high levels of obesity and non-communicable diseases that are being recorded in developed countries.

In this complex scenario: how can we ensure that there will be enough safe and healthy food for everyone in the future? What can we do in Europe to make sure that



enough food will be produced and at the same time ensure its safety and quality?

The EU, with its high food safety standards, its strong food industry, its ambitious research and innovation projects, and its global efforts to achieve food and nutrition security, can and must play a crucial role in tackling food-related challenges.

The Joint Research Centre (JRC), as the European Commission's in-house science service, underpins the EU's high food safety standards with the best scientific and technical expertise available. It also supports EU efforts to foster food security on a global scale and looks at how to achieve this in a sustainable way.

The JRC's reference laboratories ensure a harmonised approach to food testing in the EU, which helps to fight food contamination and to ensure the safety of food products. Our scientists develop economic modelling tools, which

can be used to assess the impact of different policy options on European farms and agricultural markets. Furthermore, methods and reference materials developed by the JRC are also used to fight against food fraud and to protect the authenticity of European products. Global food security is also an important strand of our work agenda and JRC tools, models and datasets are used to monitor and forecast agricultural production. In order to promote a healthier society, the JRC also looks at healthy diets for disease prevention and childhood obesity, among other areas.

These are only a few examples of the food-related research activities in which the JRC is involved. This report provides a comprehensive overview of all the different types of activities that together support European policies for food.

Tuckey



Introduction

Safe and nutritious food is a universal requirement. The European Commission plays a key role in developing and implementing sound food policies that protect the well-being of consumers and safeguard public health. Ensuring that safe food reaches our plates is a complex task involving diverse actors: farmers, food producers, retailers and control laboratory personnel, among others.

The European Commission's in-house science service, the Joint Research Centre (JRC), supports Member States and laboratories worldwide in ensuring the safety and quality of our food, thereby promoting the sustainable use of resources and improving land use.

This report provides a comprehensive overview of the work of the JRC. It highlights the JRC's scientific tools, methods, analyses and activities that work towards authentic, safe and nutritious products, while respecting the environment and helping countries outside the European Union (EU) attain food security.

The JRC's work described in this publication is organised in six chapters, each focusing on a given area of research and its relevant scientific outputs, linked to its policy background and context. It also provides a list of partners, publications, contacts and useful links.

CHAPTER 1 Science underpinning EU food policy



We want our food to be nutritious and tasty, but above all, safe. From the moment a food product is grown, harvested, manufactured, produced or processed, packaged and transported, until it finally reaches our plates, several safety issues must be addressed.

The JRC supports EU legislation with scientific advice on a great variety of areas ranging from chemical residues and contaminants to food contact materials, feed and

food additives such as sweeteners, colours, flavourings, or allergens. The JRC's activities underpin the work behind the "from farm to fork" policy approach with validated methods, risk and exposure assessments, databases, reference materials, models, training courses and other scientific tools, which support national laboratories' work.

Control laboratories also have the possibility to check their performance through the JRC's proficiency testing programmes in a wide range of analytical activities. Consumers can therefore be reassured that the food they purchase in the European market has been tested to the most appropriate standards and what they eat is safe.

CHAPTER 2 Acting today for a better tomorrow: global food security



Effective actions to ensure food security call for knowledge of food demand systems at local level. The JRC designs modelling tools to understand the relationship between food consumption, farm incomes and food prices. It also studies the impact of agricultural policies on food demand in farm households in selected African countries, and evaluates new alternatives like aquaculture. JRC work supports the adequate and appropriate allocation of resources in emergencies and assists in planning food security interventions for chronic food insecurity. These scientific tools and analyses support policy decisions for prevention of and response to natural disasters, famine and food insecurity.

CHAPTER 3 Research in agriculture: outlook for our food and land



The JRC develops economic modelling tools for ex ante impact assessments of different policy options in the agricultural area. The modelling tools are part of an integrated modelling platform comprising global general equilibrium models (that assess economic impacts) and partial equilibrium models (focusing exclusively, and in more detail, on impacts in the agricultural sector). With a wide range of different models, the JRC is able to analyse policies in terms of their impact on agricultural production, markets and income, both globally and at EU level. It also evaluates their impact on environmental indicators such as greenhouse gas (GHG) emissions.

The JRC provides continuous scientific support to the Common Agricultural Policy (CAP) reform process, carrying out a wide range of analyses to assess how best to achieve the reform objectives of viable food production, sustainable management of natural resources and a balanced territorial development. Furthermore, it carries out comprehensive impact assessments to identify the best options for EU agriculture (and the dependent agri-food sector) within the EU energy and climate change policy framework post 2020.

CHAPTER 4 Food quality and authenticity



Food authenticity and quality are important for European consumers and the food industry, and essential for trade relationships in a global market. Recent food scandals have highlighted the need for a coordinated approach in the fight against food fraud.

Product traceability and correct labelling supported by scientific tools play a key role in fighting food fraud, safeguarding the quality of food products and verifying

compliance with legislation. In these areas, the JRC provides national control laboratories with databanks, technical expertise and guidelines, and through quality assurance tools such as reference materials and validated methods. They allow test results across the EU to be compared and verified, an essential condition for fighting food fraud and identifying undesired food ingredients, not only within the internal market, but also for incoming foodstuffs.

CHAPTER 5 Food for health



Unhealthy food consumption patterns, alongside other lifestyle choices, are key modifiable risk factors for many non-communicable diseases that are a major cause of morbidity and mortality. These diseases also have serious economic implications for European society .

The JRC's nutritional sciences expertise tackles childhood obesity, and promotes healthy diets for disease prevention, healthy ageing, and nutrition information for consumers. Its scientific expertise supports and promotes a healthier society.

CHAPTER 6 Fostering the innovation flow



In times of increasing concern over the planet's capacity to feed an ever-growing population, innovation in the food and feed supply chain offers solutions to help meet demand sustainably and ensure product safety and quality.

At the JRC, innovation is central to several food- and feed-related initiatives including new plant-breeding technologies, genetics and genomics in support of sustainable aquaculture or nanomaterials.

1 Science underpinning EU food policy

Although sometimes taken for granted, food safety involves over 100 000 people across the EU performing official controls over some 20 million food operators at farms, abattoirs, borders, restaurants, food industries, supermarkets or during transport. Ensuring that the EU has the highest standards for food and feed safety is key for the European Commission. It is also vital for the internal market, for protection of human health and consumer rights in relation to food. The food industry also has a strong interest in addressing safety issues throughout the food chain, in order to maintain consumers' trust and prevent costly recalls of food products.

1.1. The European food-testing infrastructure: EU reference laboratories managed by the Joint Research Centre

The JRC's activities in this area provide scientific support to the following policy initiatives:

- Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety
- Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed
- Regulation (EC) No 1830/2003 of the European Parliament and of the Council of 22 September 2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC
- Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules
- Commission Regulation (EC) No 776/2006 of 23 May 2006 amending Annex VII to Regulation (EC) No 882/2004 of the European Parliament and of the Council as regards Community reference laboratories
- Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs

- Commission Regulation (EC) No 401/2006 of 23 February 2006 laying down the methods of sampling and analysis for the official control of the levels of mycotoxins in foodstuffs
- Commission Regulation (EC) No 333/2007 of 28 March 2007 laying down the methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foodstuffs

The EU has a well-established legislative framework to ensure European consumers have access to safe and high-quality food products. This includes setting maximum limits for manmade or natural contaminants and residues and establishing procedures for authorisation of certain products that end up in the food chain.

EU Member States implement this strict legislation. The EU's legislative framework foresees requirements such as accreditation of official food control laboratories and the provision of quality assurance tools through the establishment of national reference laboratories (NRLs) and European Union reference laboratories (EURLs).

EU reference laboratories coordinate networks of national reference laboratories and provide them with quality assurance tools such as, reference methods, reference materials, proficiency-testing schemes, guidance and laboratory staff training. They support the creation of efficient networks of official control laboratories throughout the EU. EURL work boosts implementation of EU legislation: contributing to harmonisation of compliance testing, reducing the need to repeat testing and saving costs. As a result, consumers benefit from safe food products, while the EU's single market is strengthened.

The JRC manages 6 EURLs that deal with food and feed issues. Through these, the JRC supports a harmonised approach to food safety testing of EU Member States, industry and stakeholders. Four EURLs manage food safety control (heavy metals, mycotoxins, polycyclic aromatic hydrocarbons, and food contact materials) and two are additionally involved in the premarketing authorisation of feed additives and genetically modified food and feed (GMFF). The JRC-managed EURLs are all ISO 9001 and ISO/IEC 17025- accredited.

The JRC frequently collaborates with the European Food Safety Authority (EFSA). EFSA is responsible for carrying out risk assessments of food and feed safety and of GMOs, and regularly uses data and results obtained by the JRC.

Methods developed and/or validated by the EURLs often form the basis for European or international standardisation, carried out by the European Committee for Standardization (CEN) or by bodies such as the International Organization for Standardization (ISO). Standards provide the means to fulfil the requirements of food and feed control legislation across Europe in terms of official testing methods.

Mycotoxins: mouldy fruits, cereals and vegetables may contain toxins

JRC activities in this area provide scientific support to the following policy initiatives:

- Council Regulation (EEC) No 315/93 of 8 February 1993 laying down Community procedures for contaminants in food
- Directive 2002/32/EC of the European Parliament and of the Council of 7 May 2002 on undesirable substances in animal feed
- Commission Recommendation of 17 August 2006 on the presence of deoxynivalenol, zearalenone, ochratoxin A, T-2 and HT-2 and fumonisins in products intended for animal feeding
- Commission Regulation (EC) No 401/2006 of 23 February 2006 laying down the methods of sampling and analysis for the official control of the levels of mycotoxins in foodstuffs
- Commission Recommendation of 27 March 2013 on the presence of T-2 and HT-2 toxin in cereals and cereal products
- Commission Decision of 12 August 2002 implementing Council Directive 96/23/EC concerning the performance of analytical methods and the interpretation of results
- Commission Recommendation of 11 August 2003 on the prevention and reduction of patulin contamination in apple juice and apple juice ingredients in other beverages (Text with EEA relevance) (notified under document number C(2003) 2866)
- Commission Decision of 20 December 2007 approving the pre-export checks carried out by the United States on peanuts and derived products thereof as regards the presence of aflatoxins
- Commission Regulation (EC) No 1152/2009 of 27 November 2009 imposing special conditions governing the import of certain foodstuffs from certain third countries due to contamination risk by aflatoxins and repealing Decision 2006/504/EC
- Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs

Fruits, cereals and vegetables constitute a crucial part of our diet. European legislation sets limits for the mycotoxins they may contain, in order to ensure their safety. Mycotoxins are toxic substances produced by fungi growing in food and animal feed. They are formed during cereal growth or post-harvest storage of crops, but also on final food products when not stored or handled appropriately. It is estimated that about 20% of food products, mainly of plant origin, may be contaminated with mycotoxins.

The EURL for mycotoxins currently covers aflatoxins, ochratoxin A, patulin, deoxynivalenol, zearalenone, fumonisins B1 & B2 and T-2 and HT-2 toxin, and ergot alkaloids and is about to extend its activities to also cover emerging mycotoxins such as *Alternaria* toxins, sterigmatocystin, enniatins, beauvericin, moniliformin, and diacetoxyscirpenol. The JRC also produces and distributes reference materials for mycotoxin testing. In addition, several analytical methods have been validated by this EURL, enabling official control laboratories to use them.

The EURL for mycotoxins has organised several proficiency tests over the years: these include the analysis of aflatoxin B1 in baby food, maize powder and animal feed, and the determination of ochratoxin A in paprika and chilli. Some of these substances are found in cereals and in a wide range of stored or processed products including coffee, beer, dried fruit, wine, cocoa and nuts. At high levels, these substances pose severe health risks, like liver or kidney damage. Other tested substances such as patulin, a mycotoxin found in rotting apples, may spread along the food chain in products such as apple juice, baby puree and cider.



JRC scientist verifying instrument settings for mycotoxin analysis.

JRC proficiency-testing exercises give national laboratories the opportunity to measure their performance and provide them with validated methods and training courses. This reassures consumers that the food they purchase on the European market has been tested to the most appropriate standards.

In April 2014, the JRC released a certified reference material for mycotoxin testing in maize, supporting quality control and assessment of performance characteristics of analytical methods, and supporting reliable measurements of mycotoxins in maize powder. The use of reference materials developed by the JRC helps food control laboratories to implement EU legislation.

Grilling, roasting and smoking flavourings and polycyclic aromatic hydrocarbons

JRC activities in this area provide scientific support to the following policy initiatives:

- Regulation (EC) No 2065/2003 of the European Parliament and of the Council of 10 November 2003 on smoke flavourings used or intended for use in or on foods
- Commission Regulation (EC) No 627/2006 of 21 April 2006 implementing Regulation (EC) No 2065/2003 of the European Parliament and of the Council as regards quality criteria for validated analytical methods for sampling, identification and characterisation of primary smoke products
- Commission Implementing Regulation (EU) No 1321/2013 of 10 December 2013 establishing the Union list of authorised smoke flavouring primary products for use as such in or on foods and/or for the production of derived smoke flavourings
- Regulation (EC) No 1334/2008 of the European Parliament and of the Council of 16 December 2008 on flavourings and certain food ingredients with flavouring properties for use in and on foods and amending Council Regulation (EEC) No 1601/91, Regulations (EC) No 2232/96 and (EC) No 110/2008 and Directive 2000/13/EC
- Commission Regulation (EU) No 836/2011 of 19 August 2011 amending Regulation (EC) No 333/2007 of 28 March 2007 laying down the methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foodstuffs

Smoked bacon, ham, fish, sausages, and smoked flavoured snacks are easily available at supermarkets. Their flavour may be the result of traditional smoking or the addition of liquid smoke flavours. Smoked foods in general might raise health concerns, because smoke contains several harmful substances, including polycyclic aromatic hydrocarbons (PAHs) at very low concentrations. Smoke flavourings are produced from smoke that is purified to remove some of these substances: they are complex mixtures containing more than 400 volatile substances and numerous non-volatiles. They are generally considered to be less of a health concern than the traditional smoking processes, and EU legislation regulates the amount that may be added into food.



Traditionally smoked foods may contain high PAHs levels.

Liquid smoke has been used extensively in food systems for flavour characteristics similar to traditional smoked food products. Currently, there is no method to measure how much smoke liquid has been added to food. Commercial production and purification involve proprietary or patented information that companies do not disclose. The JRC is developing the related testing methods and tools required in this instance. Scientists are elucidating the chemical composition and characterisation to understand the batch-to-batch and product-to-product variability of several primary liquid smoke preparations. This should help to identify appropriate markers to measure the amount of smoke flavouring added to food. The findings of this research will support the correct implementation of legislation, as it is currently difficult to verify compliance.

PAHs may be formed during the incomplete combustion of organic compounds and can be found in the environment. Some of them pose risks to human health. We are exposed to PAHs via air and drinking water, but mostly through food intake. Food contamination with PAHs is attributable mostly to production practices. Grains and raw products for the production of edible oils, e.g. olive oil and soya bean oil, may be contaminated with PAHs through drying processes. Food of animal origin, however, is mainly contaminated through processing, e.g. charcoal grilling, roasting and smoking. Within the EU, the maximum limits of 4 PAHs are regulated, and the monitoring of 16 PAHs is recommended.

The JRC-managed EURL for PAHs coordinates activities to develop and improve analysis methods for the official control of maximum levels of PAHs. It periodically arranges proficiency testing to benchmark the capabilities of national network members.

The EURL PAH has developed and validated a method for implementing EU legislation on PAH contents of food in all regulated food categories. The method was accepted for standardisation by CEN and is available as EN 16619:2015.

Feed additives and feed safety

JRC activities in this area provide scientific support to the following policy initiatives:

- Regulation (EC) No 1831/2003 of the European Parliament and of the Council of 22 September 2003 on additives for use in animal nutrition
- Regulation (EC) No 885/2009 of 25 September 2009 amending Regulation (EC) No 378/2005 as regards reference samples, fees and the laboratories listed in Annex II
- Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules
- Commission Regulation (EU) No 56/2013 of 16 January 2013 amending Annexes I and IV to Regulation (EC) No 999/2001 of the European Parliament and of the Council laying down rules for the prevention, control and eradication of certain transmissible spongiform encephalopathies

Since food of animal origin represents a significant part of many people's diet, the feed necessary for raising livestock must comply with strict quality and safety standards. Feed additives are an integral part of modern animal husbandry, combining high performance in production with animal health and welfare. Such additives may not be put on the market without prior authorisation from the European Commission. Authorisation is only granted following an EFSA scientific evaluation that demonstrates the efficacy of the additive and the absence of harmful effects to human and animal health and to the environment.

The JRC-hosted EURL for feed additives supports EFSA and assesses the validity of analytical methods for the analysis of feed additives for the authorisation process. It also coordinates the network of NRLs.

For instance, in 2013, the JRC developed and validated a rapid and efficient method to detect and quantify 48 antibiotics in feed. The method is based on emerging technology and is a useful tool for the compulsory monitoring of undesirable substances in the feed and food chain.



JRC scientists applying field-flow fractionation for characterisation of nanoparticles in feed additives.

This innovative method provides Member States' laboratories with rapid, simple, straightforward and reliable control of 48 antimicrobial agents from different classes in complex animal feed materials.

Reintroducing processed animal proteins into aquaculture

Following the events related to bovine spongiform encephalopathy (BSE), commonly known as mad cow disease, the JRC developed a specific marker for processed animal proteins (PAPs) obtained from diseased animals or from specified risk materials such as bovine brain and spinal cord, that must not enter the feed–food chain. In 2013, the JRC also released a reference material (IRMM-AD482) to facilitate the correct implementation by control laboratories of a test that can detect ruminant PAPs in feed material obtained from non-ruminants. These tools made it possible to re-authorise PAPs derived from healthy non-ruminant farmed animals (pigs and poultry) to be used in fish feed as of June 2013. The re-authorisation is expected to improve the overall sustainability of the aquaculture sector, since these PAPs could replace fishmeal, which is a scarce resource.

Moreover, in collaboration with the EURL for animal proteins in feeding stuffs (EURL AP) operated by the Walloon Agricultural Research Centre (CRA-W), the JRC contributed to the validation of new diagnostic spectroscopic and DNA-based methods for identifying PAPs from different animal species. The new Commission Regulation (EU) No 51/2013 of 16 January 2013 includes these validated methods, which are based on the polymerase chain reaction (PCR) for the detection of animal constituents in feed.

The JRC has helped develop statistical tools to validate methods that provide binary information such as 'present' or 'not present'. They can be applied to the validation of screening methods, which are rapid and less expensive, performed by official control laboratories and industry. Many samples are analysed, and only those raising red flags in the initial screening subsequently undergo more expensive confirmatory methods. The results of this research are included in the development of new international standards.

Heavy metals

JRC activities in this area provide scientific support to the following policy initiatives:

- Commission Regulation (EC) No 333/2007 of 28 March 2007 laying down the methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foodstuffs
- Directive 2002/32/EC of the European Parliament and of the Council of 7 May 2002 on undesirable substances in animal feed

- Commission Regulation (EU) No 1275/2013 of 6 December 2013 amending Annex I to Directive 2002/32/EC of the European Parliament and of the Council as regards maximum levels for arsenic, cadmium, lead, nitrites, volatile mustard oil and harmful botanical impurities
- Commission Regulation (EU) No 836/2011 of 19 August 2011 amending Regulation (EC) No 333/2007 laying down the methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foodstuffs

While some trace elements i.e. selenium, iron and zinc, have nutritional functions and are essential to health, others such as arsenic, lead, cadmium and mercury, are considered toxic, and their presence in food may seriously affect human health.

Heavy metals are found naturally in the environment: they accumulate as a result of anthropogenic activities or through the food chain as in the case of seafood. Appropriate health protection of vulnerable groups might call for the lowest levels achievable. Reliable analytical methods are needed to determine the content of these heavy metals in food and feed matrices, something facilitated by the JRC's European Reference Laboratory for heavy metals (EURL-HM).

Methylmercury is a contaminant that can affect the development of the nervous system. The major source of methylmercury intake in humans is fish. Swordfish and tuna are reported to contain high levels of methylmercury. At present, no maximum limit has been introduced for methylmercury in European legislation, due to lack of standardised methods.

In collaboration with the Instituto Português do Mar e da Atmosfera (IPMA) and the Laboratori Agència Salut Pública de Barcelona, the JRC-managed EURL-HM successfully validated a rapid and cost-efficient method. This standard operating procedure, available from the EURL-HM website, is currently being evaluated by CEN in order to become a European standard.

Food contact materials

JRC activities in this area provide scientific support to the following policy initiatives:

- Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC
- Commission Regulation (EU) No 10/2011 of 14 January 2011 on plastic materials and articles intended to come into contact with food
- Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004

on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules

Our food may also be exposed to contaminants while being cooked, prepared, packed or stored. Packaging for instance, plays a critical role to protect food against contamination and is essential to maximise shelf life. Yet, these materials must be safe. Their safety relies on ensuring that no release of chemical substances occurs in unsafe levels from materials involved in the food processing chain, packaging or kitchen ware, into the food. EU legislation therefore limits the level of substances these food contact materials may release. These include plastics, paper and board, cellulose, coated metals, ceramics, silicones and rubbers, as well as sustainable bio-based materials and innovative materials such as nanomaterials and active/intelligent packaging materials.

Migration of harmful chemicals can also occur from printing inks used in food-packaging material. The JRC developed and validated a specific method to measure the migration of a vast range of ink components into different foods, including dry foods such as cakes, pasta and milk powder. This research led to the revision of Regulation (EU) No 10/2011 for plastics, which now includes specific testing for dry foods.

The JRC also investigated plasticisers used in jars for baby foods, resulting in an exposure assessment of infants consuming commercial infant foods. The data were used in an EFSA evaluation establishing the basis for new laws regulating lids in a stricter manner. For the correct implementation of these directives, the JRC provided training to laboratories, and organised comparative tests to assess how well official control laboratories performed.

JRC research also includes the monitoring of specific migrating substances from kitchenware articles. Recent projects have focused on imports of plastics utensils for substances like formaldehyde from melamine bowls and trays, primary aromatic amines from polyamide kitchen spatulas as well as from coloured-paper napkins. Current research focuses on the release of different metals from ceramic tableware, bakeware or crystalware. The JRC is providing scientific data on the substances that can migrate from these products such as colors and glazings. JRC scientists are developing fast and easy-to-perform tests that mimic the repeated home-use by consumers eating different foods.



Safety testing of kitchenware.

The EU Rapid Alert System for Food and Feed (RASFF) has recently highlighted elevated levels of chemical releases from kitchenware imported from third countries; leading to the restriction of some imports. Since goods circulate freely once in the EU, their inspection at the point of arrival should be reliable. The JRC has developed guidelines for sampling and testing to improve the cost-effectiveness and robustness of laboratory tests. Today, these guidelines are recognised worldwide and provide a solid basis for the harmonised enforcement of EU legislation. The JRC has also organised training and proficiency tests to improve the performance of official controls in the EU. As a result, non-compliance has decreased significantly from 11% to 1%, following the restriction of some imports. The guidelines and the proficiency exercises have eliminated discrepancies in test conditions, and provided a solid basis to enforce legislation.

The JRC-hosted EURL for food contact materials (EURL-FCM) also assesses the proficiency of control laboratories, to ensure EU Member States achieve comparable and reliable analytical results. The EURL FCM has developed databases of more than 450 substances and over 300 methods for regulated “food contact material” substances for compliance and enforceability. It assesses the proficiency of laboratories to make sure EU Member States achieve reliable analytical results.

The JRC also studies how different contaminants can migrate into foods and provides the data to develop tools for exposure assessment. It was a major partner in FACET, a large European Project focusing on additives, flavourings and food contact materials. FACET is also a desktop software application developed by the JRC, containing databases of chemical concentrations for these substances, industry data on retail packaging composition, and food consumption diaries. In December 2013, the JRC launched a downloadable tool of FACET.

Work in progress

There are currently more than 930 substances authorised for plastics alone, and only 28 official detection methods exist. It is therefore essential to develop further suitable methods for measuring migration of chemicals from packaging into food.

There is no EU-specific legislation for materials other than plastics, posing a high risk from transfer of their constituents into food: printing inks, coatings, silicones, adhesives, rubber, metals, paper and board, nanomaterials and combinations of materials. With more than 10 000 chemicals used in different materials, there is a need to anticipate policymaking needs in non-regulated areas. The JRC is becoming an integrated key element in impact assessments, to ensure that enforceability is foreseen *ex ante* and remains feasible at all stages. The JRC will also support the provision of data on exposure and identification of health risks of new materials and technological advances supporting innovation.

Genetically modified food and feed

JRC activities in this area provide scientific support to the following policy initiatives:

- Directive 2001/18/EC of the European Parliament and of the Council of 12 March 2001 on the deliberate release into the environment of genetically modified organisms
- Regulation (EC) No 1829/2003 of the European Parliament and of the Council of 22 September 2003 on genetically modified food and feed
- Regulation (EC) No 1830/2003 of the European Parliament and of the Council of 22 September 2003 concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC
- Regulation (EC) No 882/2004 of the European Parliament and of the Council of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules
- Regulation (EU) No 619/2011 of the European Parliament and of the Council of 24 June 2011 laying down the methods of sampling and analysis for the official control of feed as regards presence of genetically modified material for which an authorisation procedure is pending or the authorisation of which has expired
- Commission implementing regulation (EU) No 503/2013 of 3 April 2013 on applications for authorisation of genetically modified food and feed in accordance with Regulation (EC) No 1829/2003 of the European Parliament and of the Council and amending Commission Regulations (EC) No 641/2004 and (EC) No 1981/2006
- Commission implementing regulation (EU) No 120/2014 of 7 February 2014 amending regulation (EC) No 1981/2006 on detailed rules for the implementation of Article 32 of regulation (EC) No 1829/2003 of the European Parliament and the Council as regards the Community reference laboratory for genetically modified organisms

In the EU, the presence of GMOs in food and feed is only allowed when strict legal requirements for authorisation, including risk assessment and labelling are fulfilled. Laboratories across Member States must verify that only authorised GMOs are used in the food and feed chain. If a GMO is not declared, legislation limits its presence to a maximum level of 0.9%.

Correct labelling requires both detection and quantification of very small amounts of GMOs. The JRC's European Union Reference Laboratory for GM Food and Feed (EURL GMFF) is responsible for validating methods for the detection, identification and quantification of GMOs in food and feed, developed by the industry and provided in the context of an authorisation of a GMO-event for entering the EU food and/or feed-chain.



JRC's certified reference materials are distributed to testing and control laboratories world wide.

Together with a positive risk assessment, the availability of an EURL GMFF validated GMO detection method is a precondition for authorisation. So far, the JRC has validated over 90 methods, which are available in the GMOMETHODS database. The JRC also develops and optimises methods and tools for control laboratories.

The JRC GMOmatrix is an online tool that allows control laboratories to plan and evaluate their initial screening strategy. It also allows them to verify which GM-events they can detect with their portfolio of screening methods. As the tool is fully based on bioinformatics, it allows to classify matches by the degree of difference between the target sequence (characteristic for the GM-event) and the probe-sequence used by the method.

The JRC is one of the major actors in the GMO analysis field. It chairs the European Network of GMO Laboratories (ENGL), with over 100 participating control laboratories, including all National Reference Laboratories (NRL) of the 28 Member States. Together with the European Union Reference Laboratory for GM Food and Feed (EURL GMFF), the ENGL has established method performance criteria.

As a recognised leader in training and capacity building for GMO analysis around the world, the JRC collaborates with over 100 countries. Many organisations from Asia, Africa and Latin America have been trained by JRC experts; consequently, an increasing number of countries use JRC's reference methods in their own GMO control. This helps avoiding trade conflicts. As a side effect of its training efforts, the JRC has initiated a number of regional GMO-lab-networks in Asia, Africa, Latin America, and most recently, the Middle East and North Africa region. Through such network cooperation, the JRC reference methods are viewed as the global, de facto gold standard for GMO detection, identification and quantification.

The JRC also develops and produces certified reference materials required for the calibration and quality control of validated methods for GMO detection, identification and quantification. It has produced close to 30 sets of certified reference materials for different genetically modified plants (maize, soybean, potato, sugar beet and cotton), which are distributed to testing and control laboratories globally. In 2013, the JRC released the first worldwide mixed

powder reference material of rapeseed powder GMO, allowing better quality control at the labelling threshold.

1.2. Monitoring radionuclides in the environment and food

Radioactivity is present everywhere. Naturally-occurring radioactive materials are present in our food and water, and even our bodies contain naturally occurring radioactive elements. At low and natural levels, this is not a concern. However, high activities of radioactivity may harm human health and EU legislation requires the monitoring of radioactivity in food, feed and drinking water.

After the nuclear accidents of Chernobyl and Fukushima, radionuclides are still migrating across different layers in the atmosphere. They can reach the ocean and soil and extend across the food chain. For instance, mushrooms growing in certain areas might contain high levels of caesium-137, a radionuclide that when accumulated in extremely high levels can disturb chemical processes in our bodies and might be dangerous. In dairy products such as milk, extreme accumulation of high levels of iodine-131 could cause thyroid problems and pose health risks, especially to children.

It is therefore of utmost importance to regularly monitor radioactivity in the environment and in food. However, it is extremely difficult for monitoring laboratories to use one dedicated measurement method for each radionuclide, as there are thousands of them. Such methods are now being replaced by spectrometric techniques to identify and quantify individual radionuclides. Proficiency-testing and reference materials of greater diversity are needed more than before, something being tackled by the JRC, which also provides training courses to laboratories across EU countries.

In assessing the population's total exposure to radioactivity, natural radioactivity found in food products has become an important source of information. In 2013, the JRC issued a bilberry reference material with certified content of caesium-137, strontium-90 and potassium-40. This reference material works as a calibration or validation source for radioactivity measurements of many types of food and feed.

It supports laboratories across Member States and helps them achieve accurate and comparable results. Food control laboratories can also use this material to ensure the quality of their data. The JRC has also been asked to contribute to the standardisation of procedures used in Member States for radioactivity monitoring of radiocaesium (^{137}Cs and ^{134}Cs) in food and feed.

1.3. Food allergens: validating testing procedures to detect allergens and gluten in food

JRC activities in this area provide scientific support to the following policy initiative:

- Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers

It is estimated that 20 million EU citizens suffer from food allergies. EU legislation requires labelling for foods that contain the 14 most prevalent offending components, including eggs, milk and nuts. Labelling is straightforward when these allergens are intentionally present, but much less so when cross-contamination occurs due to the shared use of facilities and production equipment. The common 'may contain' label is used as a result, often leaving the European consumer confused about the actual allergen levels and the real safety of the product.



Sample preparation, extraction and clean-up of wine allergenic proteins by dialysis.

Food producers, clinicians and allergy patient groups are making a concerted effort to set safety thresholds. The JRC is participating in the EU-funded project 'Integrated approaches to food allergen and allergy risk management' (IFAAM), which aims to provide an evidence-based risk management of food allergies.

The JRC is also developing and validating analytical methods for allergen detection in processed foods. This includes molecular biology methods based on the detection of DNA originating from the allergenic ingredient; immunochemical methods based on enzyme-linked immunosorbent assays (ELISA) of the allergy-eliciting proteins as well as mass

spectrometry of peptides derived from those proteins.

Global harmonisation and standardisation of detection methods is also high up on the JRC's list of scientific support objectives. This will ensure that consumers can trust the labels on the food they buy.

1.4. Gluten intolerance

JRC activities in this area provide scientific support to the following policy initiative:

- Commission Regulation (EC) No 41/2009 of 20 January 2009 concerning the composition and labelling of foodstuffs suitable for people intolerant to gluten
- Commission Implementing Regulation (EU) No 828/2014 of 30 July 2014 on the requirements for the provision of information to consumers on the absence or reduced presence of gluten in food

Intolerance to food products varies from one individual to another. Coeliac disease for instance, is an autoimmune disorder caused by gluten proteins found in wheat, barley and rye, for instance, and resulting in a life-long intolerance of gluten. Currently the only solution is to eliminate gluten from the diet of sufferers.

EU legislation regulates the levels below which a food can be marketed as 'gluten-free' or 'low gluten'. These levels are set at 20 mg/kg and 100 mg/kg respectively in the final food product. The enforcement of these thresholds requires the measurement of gluten levels in a wide variety of foods, but the measurement of gluten in food products is far from simple.

The JRC is actively involved in assessing the comparability of measurement results in a variety of complex foods using different analysis methods. This includes the comparison of results from various analytical test kits available in the market, across diverse food matrices. The JRC is currently assessing new approaches to gluten quantification and the standards required for comparable measurements across different measurement platforms, as well as approaches for the detection and quantification of multiple marker molecules i.e. peptides, and the quantification of these markers (and subsequently gluten) using molecular techniques.

The JRC has produced internationally accepted guidelines for the validation of rapid-based ELISA test methods for food allergens and gluten together with a group of international regulatory agencies i.e. the US Food and Drug Administration and Health Canada. This initiative has allowed the introduction of test-kits that follow the guideline into the market. These guidelines are in the process of being adopted or endorsed by international standard developing organisations such as Codex Alimentarius, the European Committee for Standardization (CEN) and AOAC International.

2

Acting today for a better tomorrow: global food security

More than 800 million people face hunger worldwide. Crises and natural disasters frequently aggravate the situation of vulnerable households already affected by poverty, social instability, diseases and hunger.

Food availability and prices, access to food and the allocation of resources all have an impact on food security. Environmental conditions, such as lack of rainfall, condition agricultural production and therefore the availability of food.

According to the Food and Agriculture Organization (FAO), demographic growth and changes in diets and incomes are likely to cause demand for food to grow by 60% by 2050. The current outlook of increasing global demand is mirrored by considerable uncertainties of supply linked to unpredictable economic, political, climatic and biological changes, e.g. new crop and animal diseases.

The EU is a leading international actor in the effort to improve global food security. Rural economic development and relief interventions in food crises are deeply anchored in the EU policy framework, from the 'Agenda for Change' and the Millennium Development Goals to the latest European Development Fund programming.

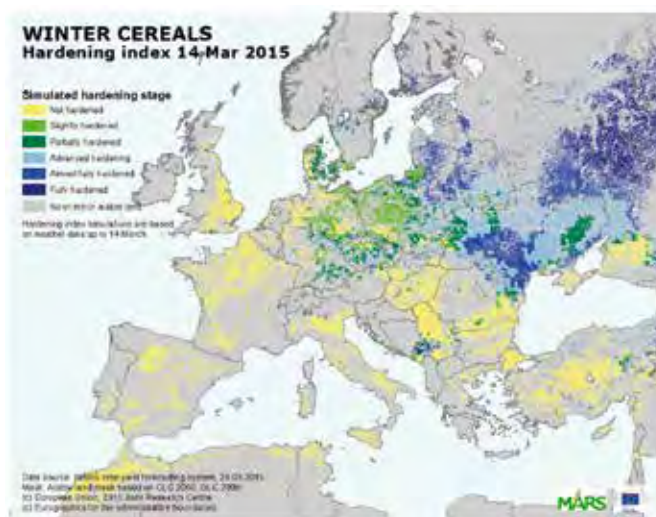
The JRC is developing several scientific tools for modelling, data management and monitoring, and is at the forefront of international scientific developments on food and nutrition security information and analysis.

2.1. Monitoring agricultural resources for food security

JRC activities in this area provide scientific support to the following policy initiatives:

- Communication from the Commission of 13 October 2011 - Increasing the impact of EU development policy: an agenda for change, COM(2011) 637
- Communication from the Commission of 7 December 2011 - Preparation of the multiannual financial framework regarding the financing of EU cooperation for African, Caribbean and Pacific States and Overseas Countries and Territories for the 2014-2020 period (11th European Development Fund) COM(2011) 837
- Communication from the Commission of 7 December 2011 - Establishing a financing instrument for development cooperation, COM(2011) 840

Planning and implementing development activities and emergency interventions to improve food security require detailed agricultural monitoring information, e.g. crop yields and area, as well as information on factors limiting agricultural production. Backed by over 20 years of experience in crop monitoring and modelling, the JRC uses global data sets based mainly on satellite observations and meteorological information to monitor seasonal agricultural performance. It provides timely, detailed reports whenever crop production is affected by water or temperature stress.



Winter cereals hardening index showing their frost tolerance.

New satellite data with higher spatial and temporal resolution will be available thanks to Copernicus, the European Earth Observation programme managed by the European Commission. The JRC will play a central role in further improving the timeliness and accuracy of global agricultural monitoring.

The main JRC research activities in this area include: improving early drought detection and assessing its impact on agriculture; developing and disseminating tools to process and interpret large time series of satellite data; improving agricultural statistics and carrying out impact assessments on adaptation of crop systems to climate change.

For this purpose, the JRC works closely with international organisations such as FAO and the World Food Programme (WFP), identifying knowledge and data gaps, and coordinating research activities.

The JRC also supports technology transfer and capacity-building of national and regional food security information systems, with a specific focus on EU-funded projects.

It is also active in organising and promoting dedicated scientific networks, and holding scientific workshops to advance and coordinate global crop monitoring experts and organisations.

The JRC, in collaboration with other research institutions, has developed a series of agricultural monitoring approaches to support the European Common Agricultural Policy (CAP). These approaches are based on European information and communication technologies including space-based Earth observation, geographical information systems and agrometeorological modelling. The transfer, adaptation and local application of these e-agriculture practices will help policymakers in developing countries to manage crisis and sustain agriculture growth. Feedback from this action will also enhance the applicability of European crop production forecasting technology on a global scale, strengthening its capacity for global monitoring of food security.

Work in progress

Although increasing agricultural productivity is the most visible challenge for future global agriculture, farming is only one of many land uses. More information is needed to understand the full impact of land use change as well as the implications of competition for land. The JRC will also strengthen its integrated approach to food security, complementing typical agricultural monitoring information with more complex food security indicators such as the economic and social dimensions of food security.

2.2. Scientific tools and methods for food security

JRC activities in this area provide scientific support to the following policy initiatives:

- Communication from the Commission of 23 February 2009 on a EU strategy for supporting disaster risk reduction in developing countries', COM(2009) 84
- Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products
- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A Decent Life for All: Ending poverty and giving the world a sustainable future
- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Supporting developing countries in coping with the crisis

- Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development

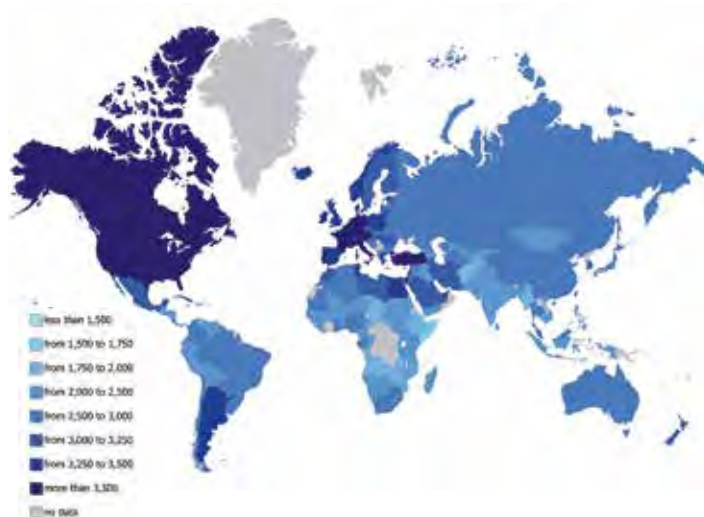
2.2.1. Data management and analyses

The JRC developed a tool to collect and manage the most relevant data sets available worldwide on agriculture, trade and related models. This initiative aimed to simplify work for analysts and modellers using data from different sources such as Eurostat, the United Nations FAO and the World Bank.

DataM provides a unique access point to data from many different sources, harmonising their format and allowing comparisons. In 2013, the African Development Bank and several of its member countries adopted the tool within the framework of a collaboration agreement. The computer application DataM was complemented with DataMweb, a web application for a portal containing the most relevant and harmonised data on different sectors of the economy. The JRC, alongside Wageningen University, is currently developing a data management system to store primary data, modelling results and documents; this will boost the efficiency and effectiveness of food security research.

Through the DataM tool more than 250 datasets from 25 different original providers are accessible to analysts and modellers allowing for the comparison of more than 120 variables and 350 commodities between all these datasets.

In collaboration with University of Bonn researchers, the JRC is developing a database of agricultural innovations that have impacted on food and nutrition security, based on a literature review. The database has been used to analyse innovations' success factors and to improve food and nutritional security. The study covers 110 food and nutritional security-related innovations from the past 30 years in agriculture and other sectors worldwide.



Total nutrition food supply in kilocalories per person per day, based on FAO's food balance sheets.

2.2.2. Modelling in support of global food security

The JRC supports EU policy with simulations and modelling techniques for projections of the evolution of food markets. These tools can anticipate and guide policy tackling food security issues at a global scale.

The JRC is also involved in the impact assessment of policies and potential trade agreements through economic modelling. Global computable general equilibrium models assess the economy-wide impacts of trade policy changes involving all sectors, while global partial equilibrium models simulate only the impacts incurred by agricultural sectors. In addition to simulations on the impact in the EU, the same instruments are adapted to assess the impact on global food security. Given the long-term dimension of this issue, a long-term modelling approach is applied in agri-food production and trade.

With the tools of JRC's iMAP, an agro-economic modelling platform, economic analyses provide insight into how different policy options could foster growth and enhance food security in different areas of the world. The agri-food sectors are investigated in the context of trade negotiations between the EU and third countries. This work has recently been undertaken for the southern Mediterranean region, with different scenarios being explored to promote the region. Simulations were carried out in the context of Euro-Med integration and trade liberalisation between the EU and Egypt, Morocco and Tunisia. The work also covered Turkey, a significant trading partner in the Mediterranean basin.

Recently, the JRC, the agricultural-economic institute of Wageningen University and researchers from Egypt, Morocco, Tunisia and Turkey used the MAGNET model to analyse four agro-economic scenarios for the southern Mediterranean region. The focus was key challenges such as non-tariff measure removal: according to projections, this could boost North African gross domestic product (GDP) by up to 2.7%. World food-price rises, investments and food waste mitigation were also analysed. Improved storage and handling are a first step towards reducing this dependency, while reinforcing food security and job opportunities beyond the agricultural sector. Fostering research, technology transfer and innovation will thus be critical.

The cereal production potential in the Euro-Asian/Black Sea region, including for instance Russia, Ukraine and Kazakhstan, is an important aspect of global food security. JRC research in this area includes estimating this region's role in grain supply to world markets, and analysing food security in the short and medium run. Developments and perspectives of the most important agricultural commodity markets, i.e. cereals, oilseeds, biofuels, milk and meat, are also covered: the focus is the potential of agricultural production, and the drivers of market developments (domestic agricultural policies and government regulations, infrastructure and market organisation, and farm structures and financing issues).

2.2.3. Better assessing food losses

The JRC started working in 2007 on a system to estimate cereal postharvest losses at provincial level for African countries. The African postharvest losses information system (APHLIS) is based on a network of local experts and each country supplies and quality controls its own data that are stored in an exclusive area of a shared database. The loss estimates are generated by an algorithm that works on two data sets, the postharvest loss (PHL) profiles and the seasonal agricultural production data. Each PHL profile is itself a set of figures, one for each link in the postharvest chain. APHLIS estimates are not intended to be 'statistics' although they are computed using the best available evidence; they give the 'best possible estimate' of postharvest losses using a transparent method of calculation.

2.2.4. Local food security in developing countries

Local food security is becoming an important component of community food structures. Subsistence and commercial agriculture are major drivers of local food security in many low-income rural areas.

In order to better understand local food security, the JRC uses micro-level methods and tools, providing detailed results and capturing diversity across households: an example is the decision-making tool known as the 'Farm System Simulator for Developing Countries' or FSSIM-Dev. It is intended for use in developing countries, to gain knowledge on local food security and rural poverty alleviation under various policy options. FSSIM-Dev is a farm household programming model, which simultaneously resolves a set of microeconomic farm models reproducing the behaviour of representative individual farm households.

The JRC actively contributes to FoodSecure, a global interdisciplinary FP7 project exploring the future of global food and nutrition security. This project aims at designing effective and sustainable strategies to assess and address the challenges of food and nutrition security.



The Farm System Simulator (FSSIM) model is being adapted to major farming systems in sub-tropical ecological zone in Western Africa.

2.3. Food market developments and uncertainty

JRC activities in this area provide scientific support to the following policy initiatives:

- Communication from the Commission of 16 April 2013 - An EU Strategy on adaptation to climate change, COM(2013) 0216 final
- Regulation (EU) of the European Parliament and of the Council of 17 December 2013 – the new Common Agricultural Policy (CAP), Reg. EU(2013) 1305, 1306, 1307, 1308

The importance of better understanding the possible evolutions of food markets in the future at global and regional scale was underlined by the 2007 and 2012 world food price peaks. The JRC's expertise in assessing food security is a valuable asset for the European Commission when dealing with policy-making initiatives for cooperation with developing countries. The JRC supports the development and implementation of policies through ex ante and ex post assessments of different policy options and scenarios, as well as through research and evaluation of the nutritional, environmental and sustainability aspects of agricultural scenarios of developing countries.

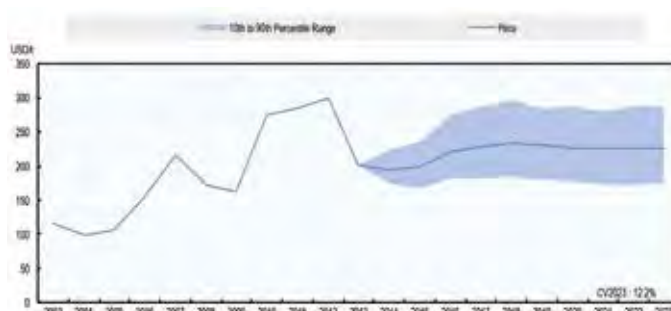
The JRC is involved in the European Commission's annual exercise for the outlook of the main agricultural commodities markets for the 10 coming years. This includes cereals, oilseeds and sugar, and their processed products (vegetable oils, meals and biofuels, and dairy and meat products). The baseline projection corresponds to the outlook for these markets and their related impact on EU farm income under a set of assumptions considered plausible (e.g. normal weather patterns), and macroeconomic assumptions on GDP growth rates, exchange rates, global price indices and world oil prices. Projections resulting from the AGLINK-COSIMO model are contrasted with expert knowledge. This baseline serves as a benchmark for any alternative scenarios and for analysis of policy options.

The JRC plays an important role in helping EU policy-makers incorporate uncertainties into their food market projections. Uncertainties exist related for example to yield and the macroeconomic context variability around the normal pattern. A partial stochastic analysis is carried out to assess to what extent such uncertainty may affect the main characteristics of the agricultural commodities' markets in future. The AGLINK-COSIMO model is run more than 500 times under different sets of assumptions representing the past yield and macroeconomic variability, and this determines a range of possible outcomes for each market.

A broader exercise is carried out globally by the Organisation for Economic Co-operation and Development (OECD) and FAO every year. The JRC contributes to these analyses, particularly dealing with the uncertainties aspect. The JRC has codified the methodology for the partial stochastic analysis, and participates in methodological improvements.

Climate change is also expected to have a global impact on crop yield, and therefore may affect food production, distribution and markets, in the longer term. The JRC works jointly in several projects with other research institutes on the potential impact of climate change on agriculture in the EU and globally, linking both biophysical and economic models.

Price volatility in the food supply chain affects the long-term competitiveness of agriculture, affecting producers and consumers, especially those unable to cope with new sources of economic uncertainty. Understanding the volatility of agricultural commodity prices and identifying its main drivers are key issues for welfare and policymakers looking to reduce the fallout.



Evolution of coarse grain historical and projected prices when uncertainties are taken into account.

The JRC is contributing by investigating from both a short- and a long-term perspective; the aim is to provide policy-makers with a comprehensive picture. In the short run, the JRC is developing new techniques exploiting state-of-the-art econometric models to determine the most important factors. The econometric and retrospective analyses provide important insights, which are incorporated into the JRC's iMAP modelling platform for long-term projections of agricultural commodity prices and their uncertainties.

Work in progress

The recent extreme fluctuations in agricultural commodity prices, especially between 2006 and 2009, have highlighted the importance of accessible, timely and accurate price data. The JRC aims to propose a cost-efficient and reliable data collection methodology and reach high frequency food price data, especially in developing countries such as Africa, by investing in new data collection tools.

The JRC report 'Agricultural commodity price volatility and its macroeconomic determinants' shows that supply-demand indicators and speculation are crucial in explaining some aspects of the volatility during the period 1986-2012. When the focus is on the period 2006 and 2012 following the price spikes, monetary factors such as low interest rates and excessive US dollar fluctuations became essential for describing agricultural price fluctuations, in particular for some of the main stable agricultural commodities such as wheat, corn and soybean.

2.4. Nutrition security and resilience

2.4.1. Combating malnutrition in developing countries

JRC activities in this area provide scientific support to the following policy initiatives:

- Commission implementing decision of 23 July 2014 adopting a Multiannual Indicative Programme for the Thematic Programme “Global public goods and challenges” for the period 2014-2020, C(2014) 5072 final
- Commission Decision on the Multiannual Indicative Programme for the Thematic Programme ‘Global Public Goods and Challenges’ for the period 2014-2020

Malnutrition is a widespread public health problem in many developing countries, claiming the lives of 2.6 million children under the age of five worldwide, every year. In addition to the loss of lives in the most extreme food crises (i.e. famines), chronic malnutrition severely impedes human and economic development. The EU has committed to help reduce the number of stunted children by at least 7 million by 2025. The JRC supports this cause by evaluating national nutrition policies in some African countries and developing tools to assess and monitor the progress of nutrition improvements.

The review of the nutrition and food security public policies in selected African countries focuses on the impact of different interventions: food fortification, public-private partnerships and agricultural nutrition-sensitive policies. The JRC is actively involved in the nutrition working group of the Integrated Food Security Phase Classification (IPC), a multi-agency initiative for standardising methods and tools that assess food security situations. The working group is developing a common nutrition classification system based on the nature of malnutrition, e.g. chronic, acute and seasonal, its severity and its prevalence.

The JRC, together with the major food security international stakeholders, is developing standard tools and methodologies to classify acute nutrition situations under the Integrated Food Security Classification (IPC) Initiative. The fully integrated IPC Food and Nutrition Security Phase Classification will include an analysis of malnutrition and its contributing factors in addition to the food security analysis. This tool will help decision-makers such as governments, ECHO and DEVCO to prioritise and target interventions.

2.4.2. Building resilience for food and nutrition security: a long-term response to food crises

JRC activities in this area provide scientific support to the following policy initiatives

- Communication from the Commission to the European Parliament and the Council of 3 October 2012 on ‘The EU approach to resilience: Learning from food security crises’, COM(2012) 586
- Commission Decision on the Multiannual Indicative Programme for the Thematic Programme ‘Global Public Goods and Challenges’ for the period 2014-2020

Worldwide, vulnerable communities and households have to face shocks ranging from drought, floods, and earthquakes to armed conflicts and economic and financial crises. These events put these people and their food and nutrition security in danger.

The JRC is a member of the Resilience measurement technical working group set up by the United Nations Food and Agriculture Organization (FAO) and the World Food Programme. Its primary objective is to provide guidance on how resilience measurement should be conceptualised, implemented, and connected to practices intended to improve food security, including the conditions on which food security depends. This resilience measurement framework is needed particularly for efficient programming and monitoring of humanitarian and development interventions funded by the EU to mitigate food crises under the Supporting Horn of Africa Resilience (SHARE) and Alliance Globale pour l’Initiative Resilience au Sahel (AGIR-Sahel) initiatives.

2.5. Outlook for fisheries and aquaculture

JRC activities in this area provide scientific support to the following policy initiatives:

- Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy
- Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Strategic Guidelines for the sustainable development of EU aquaculture - COM/2013/229 - (29/04/2013)
- Communication from the Commission to the European Parliament and the Council, Building a sustainable future for aquaculture, A new impetus for the Strategy for the Sustainable Development of European Aquaculture - COM/2009/0162 final
- Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions Blue Growth opportunities for marine and maritime sustainable growth - COM/2012/0494 final

The United Nations FAO has reported that fishery products accounted for 16.6% of the world population’s intake of animal protein (2009 data), and 6.5% of all protein consumed. A growing population will put further pressure on the supply of fisheries products. However, ac-

According to the FAO, world capture fisheries have been stagnating for over a decade and the status of ocean fish populations remains critical. A high percentage of stocks are overexploited, depleted or recovering from depletion; therefore, policy and management schemes enabling sustainable fisheries are imperative.

The JRC provides scientific support for fisheries management. It coordinates and participates in the scientific advice process of the European Commission's Scientific, Technical and Economic Committee for Fisheries (STECF) and collects and maintains fisheries data from the Member States under the Data Collection Framework Regulation. In order to improve fisheries management including control, enforcement, traceability and conservation measures, the JRC develops novel fisheries modelling and assessment approaches, and fosters new scientific technologies.

In addition, the progressive implementation of an ecosystem-based approach can establish an interaction between the sectors involved in the sustainable exploitation of the environment. This, together with a progressive consideration of fisheries as one of elements of ecosystems, will mitigate the effect of indiscriminate efforts, which may undermine future fish populations.

Aquaculture may compensate for the stagnating supply of seafood from captured fisheries, and may contribute to increasing demand. Aquaculture production has increased worldwide in the last three decades. By 2015, it is expected to provide 50% of the fishery products consumed. However, while aquaculture production is rising sharply in many parts of the world, it is stagnant in the EU. The EU's share of world aquaculture production was 2.1% in 2010. EU fisheries and aquaculture production self-sufficiency dropped to roughly 35%, while net fish imports increased to around 65%. This is why the European Commission intends to boost aquaculture through the Common Fisheries Policy (CFP).

A recent JRC study revealed that fisheries and aquaculture in coastal communities in the EU could have a significant socioeconomic impact. Aquaculture farms currently cover small surfaces within the EU. Growth limitations may be better explained by competition for and conflict over space at local level with more established economic activities such as tourism.



Aquaculture farms cultivate aquatic organisms like fish, crustaceans and water plants under controlled conditions.

2.6. JRC's food security foresight for 2030

JRC activities in this area provide scientific support to the following policy initiatives:

- Communication from the Commission of 23 February 2009 - EU strategy for supporting disaster risk reduction in developing countries, COM(2009) 84
- Directive 2010/30/EU of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products
- EU Food Security Policy Framework (SWD(2013) 104 final, Boosting food and nutrition security through EU action: implementing our commitments, 27 March 2013)
- EU Nutrition Policy Framework (COM(2013) 141, Enhancing maternal and child nutrition in external assistance, 12 March 2013)
- EU Resilience Policy Framework (COM(2012) 586, The EU approach to resilience: learning from food security crises, 3 October 2012)
- EU Food and Nutrition Security Implementation Plan 2014-2020 (SWD(2013) 104 final, Boosting food and nutrition security through EU action: implementing our commitments, 27 March 2013)
- New Alliance for Food Security and Nutrition (COM(2013) 531 final, Beyond 2015: towards a comprehensive and integrated approach to financing for poverty eradication and sustainable development, 16 July 2013)
- Policy Coherence for Development (PCD), (Council of the European Union (2013), ST 17160/13, Policy Coherence for Development (PCD) – Council Conclusions, 12 December 2013)
- Common Fisheries Policy (CFP) - (EU 2013 Report on PCD and COM(2011) 424 final on the external dimension of the CFP reform)

Despite the general consensus that food security is a key challenge, the complexity of the global food system complicates the identification of measures that would enhance its resilience and robustness. In this context, the JRC foresight study on global food security was carried out to explore what will significantly affect the world food situation in 2030, in order to identify the most useful EU policy intervention. The research question was as follows: 'What should the EU do to meet the major food security challenges the world will face by 2030?'

In response to emerging calls for the adoption of a more systemic approach to food security, the JRC foresight study suggests that a sustainable food security framework should move away from the conventional focus on individual components of the food system (e.g. the supply side, the demand side, the agricultural sector), and instead should address holistically the complex relationships between its different stages and actors. The agricultural and rural contexts are not isolated entities, but rather components of an interconnected system with rural, suburban and urban dimensions, and local, national, regional and global levels with specific effects on global food security.

Understanding future challenges of food security therefore calls for a focus on all aspects of the food system, especially trade and value chains. Moreover, the issue of access to food and its determinants (i.e. income, employment and gender, among others) must feature higher on research and policy agendas. Innovation throughout local and global food systems is also essential in fostering sustainable food security worldwide.

The study also highlights the need for better-coordinated and systematic policy dialogue and coherence on food security at EU level. Future challenges can only be addressed comprehensively through a holistic, coherent and collaborative approach on trade, research and innovation, environment, agriculture and fisheries, development, migration, and health and safety.



3

Research in agriculture: outlook for our food and land

The EU has 500 million consumers who need a reliable supply of healthy and nutritious food at an affordable price. In most EU countries, the average family spends around 15% of its monthly income on food. Many current and future challenges exist: global competition, economic and financial crises, climate change and volatility of costs of inputs e.g. fuel and fertiliser. To meet these challenges, the EU has created and implemented the Common Agricultural Policy (CAP). This sets conditions, allowing farmers to fulfil their multiple functions in society — the first of which is to produce food.

The CAP has been thoroughly reformed in the last two decades. From its initial price support focus, it has become a modernised policy, decoupled from production based on direct payments per hectare to farmers and more market-oriented.

3.1. Modelling support for the Common Agricultural Policy

JRC activities in this area provide scientific support to the following policy initiatives:

- Regulation (EU) No 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) and repealing Council Regulation (EC) No 1698/2005
- Regulation (EU) No 1306/2013 of the European Parliament and of the Council of 17 December 2013 on the financing, management and monitoring of the common agricultural policy
- Regulation (EU) No 1307/2013 of the European Parliament and of the Council of 17 December 2013 establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy and repealing Council Regulation (EC) No 637/2008 and Council Regulation (EC) No 73/2009
- Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulation (EC) No 922/72, (EC) No 234/79, No 1037/2001 and (EC) No 1234/2007
- Communication from the Commission of 22 January 2014 - A policy framework for climate and energy in the period from 2020 to 2030, COM (2014) 15

- Communication from the Commission of 18 November 2010 --The CAP towards 2020: Meeting the food, natural resources and territorial challenges of the future, COM(2010) 672 final

The JRC develops economic modelling tools for ex ante impact assessments of new CAP policy options at two levels: (a) aggregate level, i.e. impact of policy options on EU markets, income and the environment; and (b) farm level, concerning both the direct impact of policies on farms, including income and subsidies distribution, production costs, agricultural structures, as well as on farmers' behaviours (i.e. investment strategies).

The JRC has developed global computable general equilibrium models assessing economy-wide impacts and global partial equilibrium models, which simulate only impacts incurred by the agricultural sector. They are used to simulate the impacts of different policy options: the phasing out of quotas for dairy or sugar, the introduction of greening provisions in the single payment scheme (i.e. to allocate certain payments only in the case of providing specific environmental services), and options for the redistribution of payments, for example.

Farm-level modelling of the CAP

The EU-28 contains roughly 12.2 million farms with diverse endowments, specialisations and land use. Responses to a specific policy or innovation may thus differ significantly across the farming community. With this in mind, the JRC initiated the Individual Farm Model for Common Agricultural Policy Analysis (IFM-CAP) for the ex ante assessment of medium-term adaptation of individual farmers to policy and market changes. Based on Farm Accountancy Data Network (FADN) data, the main objectives of this model are to simulate the economic effects of farm-specific policies, to capture farm heterogeneity across the EU in terms of policy representation and impacts, and to assess policy effects on farm structural change. In fact, the last decade has seen a rapidly decreasing structural trend in the number of farms and active farmers throughout Europe.

In parallel, the JRC is studying several aspects of policy impacts on farms, such as subsidies and income distribution or the drivers of structural change in the EU farming sector.

As annual investment decisions affect current and future production, any policy that increases investment will influence farm output for some years. Through surveys to farmers, the JRC has been examining the impact of policy and non-policy variables on farm investments.

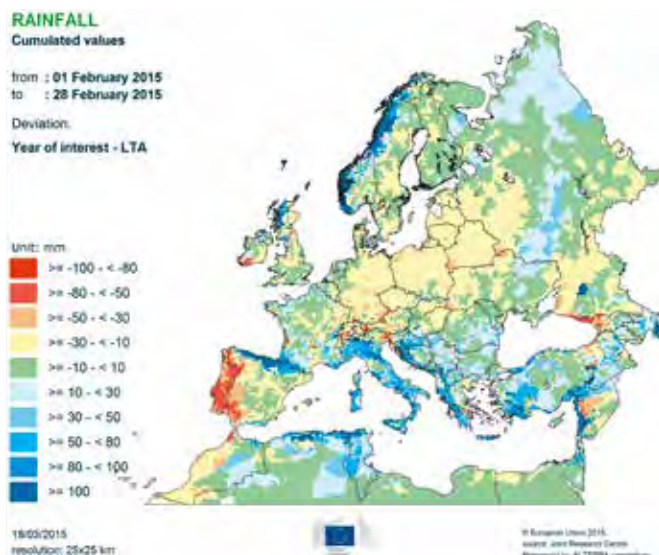
In collaboration with the Directorate-General for agriculture and rural development, the JRC has conducted a review study on the policy needs and scientific and methodological requirements in the area of farm-level modelling of the CAP reform impacts. As a result of this activity, the JRC started an in-house development of the individual farm-level model, the IFM-CAP. This model will help to better assess the impact of the CAP at disaggregated level and thus supplement the other modelling tools used by the JRC but available at aggregated sectoral and/or regional level.

3.2. Agricultural monitoring and forecasting

JRC activities in this area provide scientific support to the following policy initiative:

- Regulation (EU) No 1306/2013 of 17 December 2013 on the financing, management and monitoring of the common agricultural policy

The JRC's crop forecasting activities support the EU's CAP by providing independent and timely crop yield forecasts for Europe and the main producing regions of the world. This allows for rapid decision-making during the growing season, as JRC data and analyses help the Directorate-General for Agriculture and Rural Development in the preparation of balance sheets on cereals, oilseeds, and rice for market analyses and decisions related to CAP management, e.g. trade measures and market intervention as well as budget preparation.



The JRC produces a monthly bulletin containing yield forecasts for the main grain and tuber crops grown in Europe. Additionally, European forecasts are shared internationally as part of the Agricultural Market Information System (AMIS), which was set up by the G20 countries to enable greater transparency of agricultural supply and markets, thereby helping to limit damaging price fluctuations.

In 2013, the Quamp2 study assessed the quality of the JRC's crop yield forecasts in the EU-28 from 1993 to 2011 and determined the overall accuracy of the yield forecasts for the main crops in Europe. According to the results, the overall mean percentage error was below 2% for the crops soft wheat, barley, grain maize, sugar beet, and potato. It stayed below 5% for rapeseed, durum wheat and sunflower. Moreover, the JRC's crop yield forecasting system produced estimates with a lower error than a benchmark forecast based on the statistical trends alone. However, for single crop-country combinations, the error may be considerably higher, reaching 15%, especially when the cropped area is rather small. Exceptionally dry or wet years pose a particular challenge in yield forecasting; however, the study showed that forecast quality deteriorated significantly only in extremely wet years, while the effect of dry years was reasonably well captured.

The way ahead

Meteorological observations or sub-national crop yield statistics will help further improve forecasting accuracy. A new generation of remote sensing information with higher spatial resolution, as with the new Sentinel satellites of the European Space Agency, will open new paths for near real-time observation of the crop state.

3.3. Support to CAP implementation

To support CAP implementation, the JRC provides guidance and tools to the EU Member States when checking the validity of farmers' applications for subsidies, and helps allocate CAP subsidy payments. This includes technical assistance for compliance with requirements such as the Good Agricultural and Environmental Condition (GAEC) standards and the specific environmental farming practices of the CAP 2013 reform. Known as 'greening' elements, these encompass crop diversification and maintenance of permanent grassland.

Over the years, JRC activities have led to several innovative developments: control using the remote sensing (CwRS) technique is widely applied by Member States to check farmers' declarations; and the Land Parcel Identification System (LPIS) provides the reference database of land parcels for each Member State. The JRC is also developing a methodology to assess the regional impact of the 'greening' measures of the CAP, linking the market model of the CAP with a series of environmental indicators.

As part of the Integrated Administration and Control System, Member States have to set up a system for the identification of agriculture parcels: the Land Parcel Identification System (LPIS). It covers all agricultural areas eligible for CAP subsidies and has to be in digital format. The JRC provided all the necessary technical and scientific support to Member States to create, update and upgrade their LPIS and to be compliant with the evolving legal conditions of land eligibility for payment. Subsequently, the JRC developed a LPIS Quality Assurance method to allow Member States to verify that their LPIS fully met the requirements. Today, the Commission Regulation calls for an annual reporting by Member States based on this method (Art. 6 of EU Reg. No 1306/2013).

3.4. Indirect Land Use Change (ILUC)

JRC activities in this area provide scientific support to the following policy initiatives:

- Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources
- Communication from the Commission of 17 October 2012 – Proposal for a Directive amending Directive 98/70/EC relating to the quality of petrol and diesel fuels and amending
- Directive 2009/28/EC on the promotion of the use of energy from renewable sources COM(2012) 595

Using more first-generation biofuels will increase global demand for crops and possibly put a strain on global food security. When these crops are diverted from food to biofuels, the gap in the food supply is filled partly by the expansion of cropland worldwide, potentially resulting in further GHG emissions. Growing biofuel crops on uncultivated land may generate changes in direct land use. However, generally speaking, crops for biofuels are grown on existing arable land already used for food production, thereby causing indirect land use change (ILUC).

ILUC is commonly estimated using economic models of world agriculture. The JRC has performed various analyses of ILUC emissions from biofuels and of biofuels market developments, both from in-house modelling, e.g. with the AGLINK-COSIMO model, and in collaboration with international institutions like the International Food Policy Research Institute (IFPRI). It has also developed a methodology to estimate greenhouse gases (GHGs) resulting from global land use changes (hence ILUC). As an alternative to complex economic models, the JRC has also developed simplified methods based on spreadsheet calculations and relying on historical data. These analyses facilitate estimates of cropland expansion (and ILUC) that result from producing one unit of biofuel.

Addressing ILUC is fundamental for improving the biofuels sustainability, and for achieving the climate change

mitigation objectives of biofuel support mechanisms. However, other equally important aspects of ILUC exist besides GHG emissions. The extensive use of bioenergy crops might impact food security, biodiversity, water use and consumption, and land and forest degradation. These aspects will form key topics for future JRC studies.

3.5. Soil data and soil resources

JRC activities in this area provide scientific support to the following policy initiative:

- EU Thematic Strategy for Soil Protection (COM (2006) 231)

The JRC is a European leader in developing soil data and information systems on soil resources. Soils are the basis of food production and must be protected. The available amount of fertile soils is limited and is currently under threat from a series of soil degradation processes and from land use changes, e.g. urban expansion, housing and infrastructure development.

The JRC provides information on the distribution of soils in Europe and their current status and trends. The European Soil Data Centre (ESDAC), in close collaboration with national soil survey institutions, collects, harmonises and distributes policy-relevant soil data and information to users in the European Commission as well as to third parties and other stakeholders in Europe. The EU Soil Thematic Strategy provides the policy framework for this activity, and is based on four main pillars of activity: legislation, integration, research and awareness-raising. The JRC actively contributes to research and awareness-raising, and supports other policy Directorate-Generals in related policy areas such as food security, climate change, biodiversity protection or water quality.

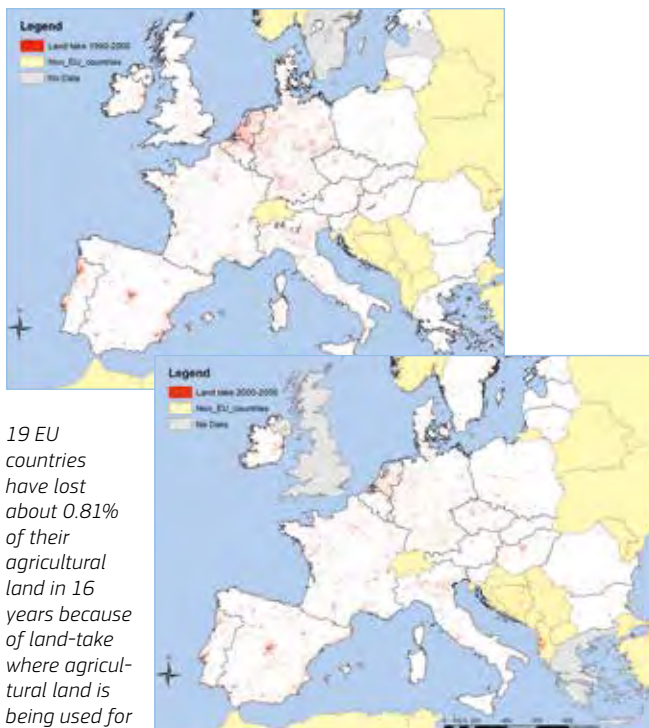
Work in progress

Soil must be considered from a global perspective. The EU is extensively using food, fibre and biomass produced on fertile soils in other parts of the world. The status and trends of these limited global fertile soil resources should be further studied. Jointly with the FAO, the JRC has been developing a voluntary partnership promoting sustainable soil management: the Global Soil Partnership.



The JRC's Soil Data Centre (ESDAC) provides information on the distribution of soils in Europe, their current status and trends.

The JRC has completed a full assessment of agricultural land-take by housing and infrastructure, highlighting its impacts on agricultural production in Europe. Agricultural land-take was calculated for the years 1990, 2000 and 2006. For 21 of the 28 EU Member States, agricultural land take was computed to be over 750 000 ha from 1990 to 2000, and more than 436 000 ha from 2000 to 2006, representing 70.8% and 53.5%, respectively, of total EU land take for these periods. The impact of this land take on the production capabilities of the agricultural sector for the period from 1990 to 2006 for 19 countries was estimated to be equivalent to a loss of over 6 million tonnes of wheat.



19 EU countries have lost about 0.81% of their agricultural land in 16 years because of land-take where agricultural land is being used for artificial purposes like building houses or roads. Land-take is an important issue as it can have an enormous impact on European food security.

3.6. Promoting environmental sustainability in the food supply chain

JRC activities in this area provide scientific support to the following policy initiative:

- Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS)
- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions of 31 January 2013 - Setting up a European Retail Action Plan, COM(2013) 36

Producing food in a way that is environmentally sustainable is among the main challenges humanity is facing.

Many companies along the food supply chain (i.e. in agriculture, food and beverage manufacturing, retail trade) have a large scope for improving their environmental performance. With motivations ranging from eco-efficiency to reputation and concerns about the sustainability of their business, many of them intend to reduce their negative impact on the environment.

In order to help companies along the whole food supply chain to reach such an objective, the JRC identifies, evaluates and documents best environmental management practices in close cooperation with the stakeholders concerned. In so doing, the JRC follows the so-called frontrunner approach, i.e. it studies those techniques, measures or actions implemented by the companies that are most advanced in terms of environmental performance. This enables the identification of best practice cross many areas in the agri-food sector, such as energy efficiency, resource efficiency, emissions, but also supply chain management. The results of this work are publicly available documents on best environmental management practices that can be used by all companies of the sector to bridge the information gap and improve their environmental performance.

This activity is part of the European Commission's work to implement the EU Eco-Management and Audit Scheme (EMAS), a voluntary framework for companies and other organisations to evaluate, report and improve their environmental performance. Within this framework, the EU decided to develop reference documents presenting best environmental management practices for a number of priority sectors. Thanks to the research the JRC has been carrying out, information on how to improve environmental performance will be available to all companies of the agriculture, food and beverage manufacturing, and retail trade sectors.

The selection of the gathered best practices is based on several techno-economic criteria. Initially, each examined sector is thoroughly investigated in order to identify the major environmental aspects and eventually to address the environmental pressures. The next step is to select the Best Environmental Management Practices (BEMPs). This procedure is based on the in-depth review of scientific literature, and interviews with experts and stakeholders. The third step is the evaluation of the performance of the different best practices according to their technical characteristics and their economic viability. Together with the identification of best practices, the JRC has also created comprehensive sets of environmental performance indicators and benchmarks of excellence which allow companies of the food supply chain to monitor their environmental performance over time and across facilities and compare with the performance achieved by the best performers in each area. These findings, validated by a technical working group for each of the sectors investigated, can significantly help to estimate the improvement potential of each organisation (i.e. company/farm/plant/shop, etc.) and to establish priorities for action.

4 Food authenticity and quality

While international collaboration on food safety is well established, it remains a challenge for food authenticity. There is a special need for international harmonisation in order to be able to detect and, what is more important, prevent or at least minimise fraud.

The fight against food fraud calls for a global approach involving cooperation and consultation among all stakeholders at all levels of the food chain. Investigations carried out by Europol suggest that organised crime syndicates are increasingly behind cases of food fraud and adulteration. Consequently, the detection and prevention of food fraud requires strategic planning and investment at national and European level involving a substantial budget.

4.1. Food labelling: the right of consumers to be informed

JRC activities in this area provide scientific support to the following policy initiatives:

- Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers, amending Regulations (EC) No 1924/2006 and (EC) No 1925/2006 of the European Parliament and of the Council, and repealing Commission Directive 87/250/EEC, Council Directive 90/496/EEC, Commission Directive 1999/10/EC, Directive 2000/13/EC of the European Parliament and of the Council, Commission Directives 2002/67/EC and 2008/5/EC and Commission Regulation (EC) No 608/2004 (Text with EEA relevance)
- Directive 2002/46/EC of the European Parliament and of the Council of 10 June 2002 on the approximation of the laws of the Member States relating to food supplements (Text with EEA relevance)

Informing consumers about the ingredients and nutritional content of their food is central to labelling legislation, as this information is essential when selecting products for a healthy diet.

The EU regulation on the provision of food information to consumers requires that processed foods display mandatory nutrition information from 13 December 2016. To support harmonised implementation of the new legislation, the JRC provided technical advice for a guidance document on tolerances for nutrition labelling purposes. Tolerances in this context are the acceptable

differences between the nutrient values declared on a label and those established in the course of official controls.



Labelling of processed food is necessary to inform consumers about the ingredients and nutritional content.

4.2. Food authenticity

JRC activities in this area provide scientific support to the following policy initiatives:

- European Parliament resolution of 14 January 2014 on the food crisis, fraud in the food chain and the control thereof (2013/2091(INI)); Text adopted: P7_TA(2014)0011
- Commission Regulation (EEC) No 2568/91 of 11 July 1991 on the characteristics of olive oil and olive-residue oil and on the relevant methods of analysis
- Commission Implementing Regulation (EU) No 1348/2013 of 16 December 2013 amending Regulation (EEC) No 2568/91 on the characteristics of olive oil and olive-residue oil and on the relevant methods of analysis
- Regulation (EU) No 1151/2012 of the European Parliament and of the Council of 21 November 2012 on quality schemes for agricultural products and foodstuffs

- Commission regulation (EC) No 607/2009 of 14 July 2009 laying down certain detailed rules for the implementation of Council Regulation (EC) No 479/2008 as regards protected designations of origin and geographical indications, traditional terms, labelling and presentation of certain wine sector products
- Council Regulation (EC) No 491/2009 of 25 May 2009 amending Regulation (EC) No 1234/2007 establishing a common organisation of agricultural markets and on specific provisions for certain agricultural products (Single CMO Regulation)
- Commission Regulation (EC) No 555/2008 of 27 June 2008 laying down detailed rules for implementing Council Regulation (EC) No 479/2008 on the common organisation of the market in wine as regards support programmes, trade with third countries, production potential and on controls in the wine sector
- Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products

Food has long been subject to fraudulent activity, e.g. watering down of milk and wine. At the beginning of 2014, the European Parliament identified several foods (olive oil, fish, honey, dairy products and meat) as particular targets of such activities. This initiative called for technologies and methods to detect food fraud.

JRC actions in the area of food authenticity include developing widely accepted standard methods of analysis and best practice guides, underpinned by advanced measurement science. These measures protect the interests of consumers who need to trust food label claims.

4.2.1. Olive oil authenticity

The EU is the leading producer and consumer of olive oil, producing 73% and consuming 66% of the world's olive oil. To reinforce the positive image and the quality of European olive oils, the European Commission set up an action plan for the olive sector in 2012. A key element of this plan was to strengthen quality control measures. The JRC identified research needs for detection of adulterated olive oil, to be addressed in a dedicated Horizon 2020 research project. The JRC is also setting up laboratory experiments to refine existing detection methods and to investigate new and promising technologies based on mass spectrometry and molecular biology.

4.2.2. European Reference Centre for Control in the Wine Sector

The EU is a leading producer of wine, and maintaining its position in global markets is of key importance. In order to enhance the reputation of European wines and preserve the best traditions of European wine-growing practices, the best available scientific know-how is necessary.

The JRC operates the European Reference Centre for

Control in the Wine Sector, which supports the correct implementation of EU wine quality legislation and aims to fight fraud in this area. For instance, the JRC plays an essential role by managing the European wine databank on authentic European wines and coordinating the network of official Member States Designated Laboratories (MSDLs). These are tools that are key in the fight against fraudulent practices such as adding sugar and watering. The JRC plays a specific part in quality control, data validation and arbitration of disputes, as well as knowledge transfer on isotopic analysis of wines to laboratories and control bodies of the new Member States.



JRC's automated distillation units for wine analysis.

4.2.3. Authenticity of organic food products

The global market for organic products in 2012 was estimated at roughly 50 billion euros, of which 21 billion euros are in the EU. The results of the European Commission's public consultation in January 2013 reviewing European organic agriculture policy revealed that 81% of respondents buy organic products because they wish to have food free from both GMOs and pesticide residues.

A new EU regulation on organic production and labelling of organic products is currently under discussion. It calls for increasing the effectiveness of controls of European and third country operators. The JRC has undertaken related work to ensure that the acclaimed specifications of organic foods can be verified objectively and independently.

The JRC has been testing several analytical methods for discriminating between organic and conventional produce, using different omics approaches (genomics, proteomics and transcriptomics) on wheat, and metabolomics on carrots. While the proof of principle has been successful for these products, these approaches need to be further refined before being used as tools for law enforcement.

The way ahead

The JRC, in close collaboration with research centres across Europe, will develop scientific methods to identify the geographical origin, grape variety and vintage of wines.

In addition, the JRC will contribute to establishing integrated databases for olive oil and organic vs conventional food commodities.

4.3. Science in support of customs tariff classification and excise duties

JRC activities in this area provide scientific support to the following policy initiatives:

- Regulation (EU) No 952/2013 of the European Parliament and of the Council of 9 October 2013 laying down the Union Customs Code
- Commission Implementing Regulation (EU) No 1099/2013 of 5 November 2013 amending Regulation (EEC) No 2454/93 laying down provisions for the implementation of Council Regulation (EEC) No 2913/92 establishing the Community Customs Code (enhancement of regular shipping services)
- Communication from the Commission to the Council and the European Parliament - Stepping up the fight against cigarette smuggling and other forms of illicit trade in tobacco products - A comprehensive EU Strategy. European Commission, Brussels, BE, COM(2013) 324 final

When goods are imported into the EU, some are subject to customs duties, and are classified according to a specific set of rules (combined nomenclature). The European Commission and the Member States cooperate to ensure the proper and uniform application of the common customs tariff nomenclature. However, in some cases, testing is needed to correctly classify goods. Because of the lack of certain analytical methods, customs administrations have to rely only on information provided by the companies. To tackle this problem, they have asked the European Commission for guidance and testing methods including definitions for differentiating product varieties. The JRC is currently developing scientific and technical tools in support of this aim.

In collaboration with DG Taxation and Customs Union and the European network of customs laboratories, the JRC is studying the effect of heat treatment on meat products using a proteomics approach. This study will help to better control quality and prevent fraudulent classification, minimising tariff duty evasion.

Work in progress

The JRC is currently developing a technique to denature alcohol intended for industrial use. The harmonisation of

denaturing practices throughout the Union will simplify administrative procedures. Moreover, the chemicals used to make alcohol unpalatable (denature) are difficult to remove, which means that the possibility of converting it to alcohol for consumption is minimised.

4.4. Coexistence of genetically modified and non-GM crops

“Coexistence” between genetically modified and non-GM crops comprises agronomic/technical segregation measures at farm level, designed to minimise the economic impacts of a mixture of GM and non-GM agricultural supplies and ensure consumer choice. Coexistence measures need to be effective in achieving its purity objectives without compromising the agronomic and economic efficiency of EU farmers.

The responsibility for developing strategies/legislation on coexistence is at EU Member state (MS) level. However, the European Commission decided to assist EU countries in the scientific/technical expertise needed for developing coexistence measures by creating the European Coexistence Bureau (ECoB) in 2008 and entrusting its operation to the JRC. It identifies efficient coexistence measures by analysis of scientific literature, study reports and empirical evidences and proposes guidelines for best practices for coexistence in assistance of MSs for development of their national rules.

In order to collect scientific evidence and to agree on these best practices for EU farmers, the ECoB operates crop-specific Technical Working Groups composed by Member States experts and managed by JRC staff. The work of the coexistence bureau is consulted with stakeholders in the food and feed chain.

Further work and further expert groups in ECoB will be dedicated to crops not yet cultivated in the EU but for which applications for cultivation have been evaluated by the European Food Safety Authority for environmental and human health risks, including also the development of technical guidance for agriculture in cross-border coexistence issues, when two neighboring EU Member States differ in their technical coexistence specifications.

The best practices developed by the European Coexistence Bureau (ECoB) are crop specific and give flexibility for the different agricultural situations in Member States. In the past 5 years, the ECoB has completed a fundamental work on best practices of coexistence between GM maize and non-GM maize in the EU for: GM maize crop production with conventional and organic farming; monitoring efficiency of coexistence measures in maize crop production and coexistence of GM maize and honey production.



5 Food for health

Daily life activities such as eating, drinking and physical activity have a huge impact on our health. In Europe today, six of the seven biggest risk factors for premature mortality are high blood pressure, elevated blood cholesterol, high body mass index, inadequate fruit and vegetable intake, physical inactivity and alcohol abuse. While half of the world's nutrition-related problems are linked to under-nutrition and nutrient deficiencies, the other half is related to energy over-nutrition and imbalanced diets. For instance, over-nutrition in the form of energy overconsumption is overtaking under-nutrition as a diet issue globally.

The JRC is providing scientific expertise in the field of nutrition, healthy ageing, overweight, and obesity-related health issues. In this way, the JRC contributes to the European Union's health and consumer policies.

5.1. Nutrition, informed food choices and disease prevention

A healthy diet has a positive impact not only on our health but also on society. Consumers often base their food choices on the information provided on labels and making the right choices involves having accurate information. The JRC is studying how diets can affect the development of certain diseases, mapping school food policies to promote healthy eating and identifying substances that could harm our health.

5.1.1. Trans fatty acids and cardiovascular diseases

JRC activities in this area provide scientific support to the following policy initiative:

- Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers

Trans fatty acids (TFA) are fats that can occur naturally in foods such as meat or milk from ruminant animals but can also be produced industrially, mainly via partial hydrogenation of vegetable oils. Consuming these TFA is associated with increased risk of cardiovascular disease, hence the latest scientific opinion issued by EFSA states that 'TFA intakes should be as low as possible within the context of a nutritionally adequate diet.'

While national legislation limits the use of industrial TFA in foods in some EU countries (Denmark, Hungary and Austria), the European Commission prepares a report on the presence of trans fats in foods and in the overall diet of the European Union's population.

The JRC is currently analysing available data on TFA content in foods and on dietary TFA intakes in Europe, which highlight room for improvement. The data gathered so far suggest that most foods in the European market hardly contain TFA. However, there are still cases where foods in some regions have high levels of TFA and sub-groups of the population may be at risk of excessive intake. The JRC is also gathering data on the policies or actions implemented worldwide aimed at reducing TFA intakes and their possible impact on all levels of society, including a cost-effectiveness evaluation.

5.1.2. Nutrition in national cancer plans

JRC activities in this area provide scientific support to the following policy initiatives:

- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions of the 24 June 2009 on Action Against Cancer: European Partnership COM(2009) 291
- White paper "Together for Health: A Strategic Approach for the EU 2008-2013", COM(2007) 630
- European Parliament Resolution of 10 April 2008, on Combating Cancer in the Enlarged Union, P6-TA(2008)0121

Low consumption of fruits, vegetables, whole grains or fibre coupled with high consumption of salt, sugars, trans and saturated fats are among the dietary factors that contribute to an overwhelming number of deaths and disability from non-communicable diseases (NCD). Cardiovascular disease and cancer are the most common NCD causes of mortality in the EU. Cancer for example, with a mortality rate of 28% causes an enormous economic and societal burden: in 2010, cancer cost amounted to EUR 126 billion in the EU.

Dietary risk factors are modifiable, if not preventable, and public health actors have a good basis for future work by focusing on them. The JRC conducted a review of the European national cancer plans to understand the degree of attention they give to dietary prevention of cancer. The analysis showed that the majority of plans acknowledge

a general link between nutrition and/or physical activity and their potential preventive effect on various types of cancer. However, more emphasis should be given on concrete measures that go beyond awareness-raising campaigns and effectively make healthy options more easily available or influence behaviour change towards healthier lifestyles and dietary patterns.

Following this review, the JRC published a report, which, along with a detailed analysis of these plans, highlights various measures that can reduce the risk of developing cancer at an individual and population level. The report aims to raise awareness of the potential of dietary prevention of cancer throughout Europe.

5.2. Healthy diets

The JRC research in this area supports the following EU initiatives:

- Communication from the Commission of 30 May 2007 – White Paper on A Strategy for Europe on Nutrition, Overweight and Obesity related health issues, COM(2007) 279 final
- Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)
- Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020)
- White Paper on a Strategy for Europe on Nutrition, Overweight and Obesity related health issues COM(2007) 279 final
- COM(2012) 083 final Taking forward the Strategic Implementation Plan of the European Innovation Partnership on Active and Healthy Ageing (EIP-AHA)

5.2.1. Healthy diets at school

Every third child in Europe is overweight or obese. Excess body weight often leads to diminished quality of life and elevated disease risk both acutely and in the long term. The associated rise in health care spending puts an additional strain on society. In response, the European Commission, the World Health Organization and the United Nations have called for action against obesity and other diet-related diseases on multiple levels and involving many different stakeholders. Along these lines, the JRC has been supporting the EU's strategy for Europe on nutrition, overweight and obesity and the childhood obesity Action Plan.

For instance, the JRC published a report in 2014 mapping school food policies across the EU. This study shows that European countries acknowledge the important contribution of school food to children's health, development and performance at school. All the countries studied have guidelines for school food, although these vary considerably. National measures aimed at promoting healthy

diets in schools range from voluntary guidelines, for example for menus and portion sizes, to complete bans, including on marketing, vending machines and sugar-sweetened drinks.

Through mapping and detailing the school food policies information throughout Europe, the JRC is helping public health policy makers, educators and researchers understand the status quo and use it as a starting point for targeted research and future intervention. The JRC's work highlights commonalities and differences between school food policies in the EU and gives quick access to source documents, thus facilitating knowledge exchange among experts in the field.

5.2.2. Healthy eating – healthy ageing?

Similar to the rest of the world, Europe is going through a demographic transition towards a much older population structure. It is estimated that by 2025, more than 20% of Europeans will be 65 or over, with a particularly rapid increase in the numbers of over-80s.

As a response, the European Commission has launched a pilot "Partnership on Active and Healthy Ageing." The JRC is supporting this partnership by reviewing the evidence on the role key nutrients and diet play in promoting healthy ageing. To achieve this, JRC scientists collected evidence on the prevention and treatment of age-related diseases with a focus on under-nutrition in older people, both a main cause and consequence of functional decline.

Micronutrients, including vitamins and minerals, and their potential effects in the prevention and treatment of age-related diseases receive special attention in the JRC review. Results suggest that the benefit from using micronutrient supplements to prevent or treat diseases in older people appears to be limited at present, although this does not imply that supplements are not effective. Whole diet approaches such as the Mediterranean diet, which contains a range of essential vitamins, minerals and bioactive compounds from natural food sources, hold promise to promote health, increase longevity and reduce risks of age-related diseases.

In 2014, the JRC published a foresight study "Tomorrow's healthy society – research priorities for foods and diets" highlighting the importance of research and innovation in shaping an effective future food system. The study supports the implementation of the Horizon 2020 Framework Programme for Research and Innovation. It has identified challenges and relevant drivers of future societal developments in the context of the food sector and the provision of foods and diets. Also, based on scenario analysis, the study has identified 10 future research and innovation priorities to move the food chain and consumption patterns towards health and well-being.

6

Fostering the technological innovation flow

In the area of food, the JRC is currently looking into new plant breeding techniques, nanomaterials, genetics and genomics in support of sustainable and efficient aquaculture, and next generation sequencing technologies for identifying food constituents.

6.1. New plant breeding techniques (NPBTs)

Plant breeding can help address the increasing food demand, the depletion of fossil resources and the impacts of climate change. It also supports the European bioeconomy policy by providing new plant varieties as feedstock for food and feed, biofuels and bio-based chemicals.



JRC supports the EC in the evaluation process to define the legislative status of new plant breeding techniques.

Since the year 2000, new plant breeding techniques have been developed as alternatives to conventional and transformation methods. Regulators, advisory bodies and academics have recently turned their attention to the legal classification and governance of NPBTs. The main question addressed is whether they significantly differ from existing techniques and how the resulting products should be classified for regulatory purposes, according to current definitions of genetic modification.

The European Commission has assembled a group of experts from national regulatory agencies to evaluate whether these new techniques constitute genetic modification and, if so, whether the resulting organisms fall within the scope of the EU legislation on genetically modified organisms (GMOs).

The JRC plays and will continue to play an international role in monitoring and evaluating the status of this sector, keeping track of the main new techniques employed in the EU and worldwide, and continually assessing the new technologies' potential in terms of application in commercial crops and for traits of interest. The JRC constantly revises a list of new plant breeding techniques that are emerging in the plant breeding scene worldwide that might trigger changes to the EU definition of GMOs and periodically updates a list of scientific publications, patents, EU field trials and data on commercialization about most relevant NPBTs.

The JRC furthermore assesses the challenges that might exist in detecting the use of these technologies in modified crops, and has a presence at international events concerning their development stage and their regulatory status worldwide.

The JRC has produced a review of the state-of-the-art new plant breeding techniques analysing their level of development, their current adoption rate by the breeding sector and their prospects as a basis for the production of commercial crops. An industry consultation and survey revealed that these techniques are already incorporated into commercial breeding programs and the most advanced crops are already in the commercialisation stage, at least in North America. The first products still correspond to simple agronomic traits e.g. herbicide tolerance, which have been used widely in the process of developing the technology. However, the examination of the stage of adoption by plant breeders reveals more complex traits at earlier development stages. The main constraints are the regulatory uncertainty about their classification in the scope of the GMO legislation. For the moment, decisions setting regulatory limits are difficult because the products of many of these techniques are not detectable or identifiable with standard methods used for GMO detection.

6.2. Genetics and genomics in support of sustainable and efficient aquaculture

Aquaculture is well-regarded as a precious source of high quality and healthy food which contributes to global food security. It serves as an efficient alternative to wild capture fisheries, helping alleviate the high pressure on commercially exploited stocks. One particular risk associated with aquaculture is the impact of escaped or released

aquaculture fish that have been undergoing adaptation to farmed conditions through selective breeding and domestication. These fish can have a negative impact on native fish populations by introducing unwanted genes when interbreeding with wild fish. This can interfere with the adaptation of wild populations to their natural environment and reduce overall population fitness.

The JRC aims to help address the European and global challenge of overcoming such risks, and developing sustainable aquaculture through improved competitiveness and environmentally friendly production.

The FP7 project AquaTrace, of which the JRC is a member, takes advantage of state-of-the-art genetic and genomic approaches to develop reliable and cost-effective molecular tools for the identification of the genetic origin of both wild and farmed fish (genetic traceability), as well as for the detection of interbreeding between farmed and wild stocks, which can be used to help understand the effects of interbreeding on key fitness traits i.e. survival and reproduction.

This research enhances our general knowledge on adaptation patterns of wild populations to local environmental conditions. Furthermore, internationally recognised forensic standards are applied to the tools developed by AquaTrace to ensure technology and innovation transfer to end-users.

The outcome of the Aquatrace project will be made available through a common database, developed and implemented by the JRC, providing long-term benefits to researchers, industry, policy makers and European consumers.

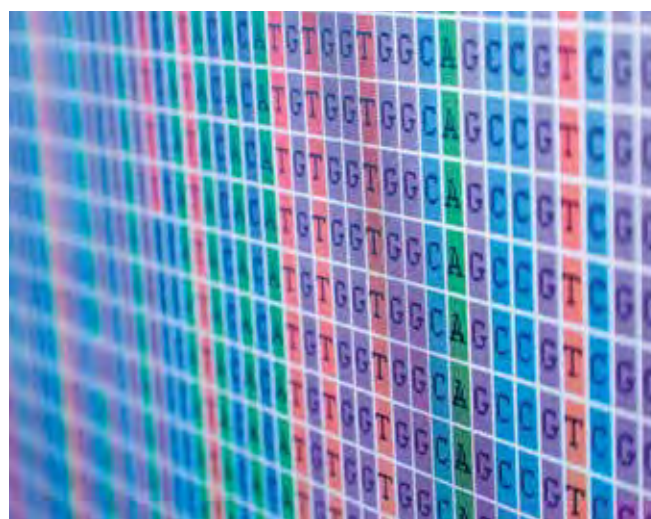
AquaTrace extensively builds on results of the FP7 project FishPopTrace, which managed to coherently establish the genetic population baseline across European waters of cod, hake, herring and common sole for the first time. Gene-associated single nucleotide polymorphisms (SNPs – the same genetic marker used in AquaTrace); allow individual marine fish to be assigned back to their population of origin with unprecedented high levels of precision. FishPopTrace showed that by applying SNP assays, for the four highly commercial target fish species on a pan-European scale, 93 to 100% of individuals could be correctly assigned to their origin in case studies. Case-targeted SNP assays were created and forensically validated, using a centrally maintained and publicly available database hosted by the JRC. These results demonstrated how application of gene-associated markers will likely revolutionise origin assignment and become highly valuable for fighting illegal fishing and mislabeling worldwide. The results also have major implications for fisheries management and conservation in general as well as for aquaculture, which is currently addressed in AquaTrace.

6.3. Next generation sequencing technologies for identifying food constituents

A wide range of detection methods have been developed in order to target DNA markers to provide information on sample compositions, ranging from species of origin to the presence of genetic modifications. These methods require both a priori knowledge of the DNA sequence to be identified, and, due to their specificity and cost, a certain expectation of what the analysed sample contains prior to the start of the testing. This requirement by current detection strategies for a priori knowledge of the sequence to be detected is rapidly fulfilled for species identification as new complete species genomes are sequenced and becoming available at an accelerated rate. However, this can limit their efficacies for new and unknown GMOs that are created and grown.

Recent advances in Next Generation Sequencing (NGS) technologies can assist in overcoming these limitations, as they have significantly decreased the time and cost required for characterising the DNA sequences of a sample; indeed, in just a few hours a single experiment can now determine a sequence of billions of DNA bases, that can then be analysed without a priori hypotheses on the type and nature of the DNA sequences present.

In 2013, the JRC established an in-house NGS facility, including an instrument and the whole laboratory and bioinformatics infrastructure required to generate, analyse and store the hundreds of gigabytes each experiment produces. In the process, unique and innovative approaches were developed in order to process the wealth of information generated. These approaches integrate the unique knowledge stored in the Central Core DNA Sequences Information System (CCSIS), a database developed, maintained and hosted at the JRC, which contains a large amount of DNA sequences, from whole genomes to specific markers, integrated with bioinformatics tools developed and/or installed locally. These facilities will enable the JRC to monitor food composition in the EU, and prevent unwanted substances from entering the food chain.



JRC's high-end DNA sequencing tools and databases allow fast and efficient monitoring of food composition.

6.4. Nanomaterials

The JRC is actively involved in research into nanomaterials safety, identification and detection, and in particular focuses on a science-based understanding of nanomaterial properties and effects, alongside development of improved measurement and testing methods.

The use of nanomaterials across several applications means they can be subject to different regulations. For instance, several regulatory provisions control nanomaterials used in the agri-food-feed sector, while some specifically address nanomaterials others cover them implicitly. In order to overcome such regulatory discrepancies, the European Commission has recommended the use of a definition for nanomaterials that is harmonised across different regulatory sectors, ensuring it has the same meaning in different application areas.

The JRC has provided scientific support to develop this harmonised definition and is contributing to its current review. In addition, the JRC continually supports the amendment of nanomaterial definitions currently in use in different regulatory sectors e.g. for the provision of food information to consumers.

The JRC is a major partner in the “NanoDefine” project, which seeks to develop an integrated approach based on validated and standardised methods to support the implementation of the EC recommendation for a definition of nanomaterial. The project consortium evaluates existing methodologies, performs rigorous intra-lab and inter-lab comparisons, and develops validated measurement methods and instruments suitable for the characterisation of nanomaterials.

The JRC also carries out work on the safety assessment of nanomaterials in different applications. Here, the physical-chemical properties, exposure and the biokinetics and toxicity of nanomaterials are investigated to determine whether their use poses any risk. The main challenge of this work is that not all currently available test methods are suitable for nanomaterials.

Furthermore, the JRC is progressively building up a nanomaterials repository and a database of test and research results (NANOhub) to ensure that the EU’s legislative actions concerning nanotechnology are based on sound information and scientific judgment.

This work is undertaken in close collaboration with the Member States, other Commission services and EU agencies, universities, research institutions and international organisations such as the World Health Organisation (WHO), the Organisation for Economic Co-operation and Development (OECD), the International Standards Organization (ISO) and the European Committee for Standardization (CEN).

The JRC together with the Dutch Food Safety Institute Rikilt has prepared an “Inventory on food additives and other food ingredients, food contact materials, and feed additives in the area of nanotechnologies” for the European Food Safety Agency (EFSA). The study aimed at providing an overview of currently used and foreseen applications of nanotechnology in the agri/feed/food sector. It reviewed how nanomaterials are regulated in the EU as well as in non-EU countries.

The results for nanotechnology applications show that food additives and food contact materials are the most indicated current applications and nano-encapsulates, silver and titanium dioxide are the most frequently used materials. Potential future developments are expected in the field of nano-encapsulates and nano-composites in applications such as novel food, food/feed additives, biocides and pesticides. The review of legislation and regulation in EU and non-EU countries shows that currently just a few EU legal acts incorporate a definition of a nanomaterial to enable specific provisions for nanomaterials. In many non-EU countries e.g., USA, Canada, Australia, a broader approach with limited nanomaterials specific legislation and/or legally binding definition of nanomaterials is applied and mainly builds on guidance for industry.

Acronyms

AMIS	Agricultural Market Information System
CAP	Common Agricultural Policy
CFP	Common Fisheries Policy
CMO	Common Market Organisation
CwRS	Control with remote sensing
DG	Directorate-General
EAFRD	European Agricultural Fund for Rural Development
EEA	European Environment Agency
EFSA	European Food Safety Authority
ELISA	Enzyme-linked immunosorbent assay
EP	European Parliament
ESDAC	European Soil Data Centre
EU	European Union
EURL	European Union reference laboratory
FACET	Flavourings, additives, and food contact materials expose tool
FADN	Farm Accountancy Data Network
FAO	Food and Agriculture Organization of the United Nations
G20	Group of Twenty
GAEC	Good Agricultural and Environmental Condition
GDP	Gross domestic product
GHG	Greenhouse gas
GMO	Genetically modified organism
ICT	Information and communication technology
IFPRI	International Food Policy Research Institute
ILUC	Indirect Land Use Change
iMAP	Modelling Platform for Agro-economic Commodity and Policy Analysis
IPMA	Instituto Português do Mar e da Atmosfera
JRC	Joint Research Centre
LPIS	Land Parcel Identification System
MSDL	Member States Designated Laboratories
NRL	National reference laboratories
OECD	Organisation for Economic Co-operation and Development
PAH	Polycyclic aromatic hydrocarbons
PAP	Processed animal proteins
PCD	Policy Coherence for Development
PCR	Polymerase chain reaction
RASFF	Rapid Alert System for Food and Feed
SHARE	Supporting Horn of Africa Resilience
STECF	Scientific, Technical and Economic Committee for Fisheries
WFP	United Nations World Food Programme

Useful tools

1. Food safety

- FACET: flavourings, additives and food contact materials exposure task
<http://expofacts.jrc.ec.europa.eu/facet/>

2. Food security

- ULYSSES - Understanding and coping with food markets volatility towards more stable world and EU food systems:
<http://www.fp7-ulysses.eu/>
- KNOEMA - open data platform:
<http://knoema.com/bdrbaze/africa-food-price-volatility>
- EMM News Brief - summary of news stories from around the world:
<http://emm.newsbrief.eu/NewsBrief/alertedition/en/IPTS-Foodsec-PriceVolInf.htm>
- SPIRITS - Software for Processing and Interpretation of Remote Sensing Time Series
<http://spirits.jrc.ec.europa.eu/>
- APHLIS - African Postharvest Losses Information System:
<http://www.aphlis.net/>
- DataM web application - Data on agriculture, trade and models:
<http://www.datamweb.com/datam/>
- FOODSECURE - An interdisciplinary research project to explore the future of global food and nutrition security:
<http://www.foodsecure.eu>
- E-AGRI - crop monitoring as an e-agricultural tool for developing countries:
<http://www.e-agri.info/index.html>
- Integrated Food Security Phase Classification (IPC) Technical Manual:
<http://www.ipcinfo.org/ipcinfo-detail-forms/ipcinfo-resource-detail0/en/c/162270/>
- CAPRI Modelling System - Common Agricultural Policy regionalised impact modelling system:
<http://www.capri-model.org/dokuwiki/doku.php?id=start>
- AgMIP project - The Agricultural Model Intercomparison and Improvement Project:
<http://www.agmip.org/>
- The MARS Crop Yield Forecasting System:
<http://mars.jrc.ec.europa.eu/mars/About-us/AGRI4CAST/Crop-Monitoring-and-Yield-Forecasting>
- MARS Bulletins:
<http://mars.jrc.ec.europa.eu/mars/About-us/AGRI4CAST/MARS-Bulletins-for-Europe>
- AGRI4CAST data resources portal:
<http://agri4cast.jrc.ec.europa.eu>

3. Agriculture and land use

- European Soil Portal:
<http://eusoils.jrc.ec.europa.eu/>
- ESDAC: European Soil Data Centre:
<http://esdac.jrc.ec.europa.eu/>
- Bioeconomy Observatory:
http://ec.europa.eu/research/bioeconomy/policy/observatory_en.htm
- Biofuels coordinating action:
<http://iet.jrc.ec.europa.eu/bf-ca/>
- Global Nitrous Oxide calculator tool:
<http://gnoc.jrc.ec.europa.eu/>
- BEMPs - Best environmental management practice:
<https://ec.europa.eu/jrc/en/research-topic/best-environmental-management-practice>
- SUSPROC - Sustainable Production & Consumption:
<http://susproc.jrc.ec.europa.eu/activities/emas/index.html>

4. Food quality

- Cocoa butter calculation (CoCal) toolboxes:
<https://ec.europa.eu/jrc/en/scientific-tool/cocoa-butter-calculation-cocal-toolboxes>
- The European Coexistence Bureau:
<https://ec.europa.eu/jrc/en/network-bureau/european-coexistence-bureau-ecob>

6. Fostering the innovation flow

- JRC Nanomaterials Repository:
<https://ec.europa.eu/jrc/en/scientific-tool/jrc-nanomaterials-repository>
- The JRC web platform on nanomaterials:
http://ihcp.jrc.ec.europa.eu/our_databases/web-platform-on-nanomaterials
- JRC GMO-Matrix:
<http://gmo-crl.jrc.ec.europa.eu/jrcgmomatrix/>
- The central core sequence information system:
http://ihcp.jrc.ec.europa.eu/our_activities/gmo/bioinformatics

Publications

1. Food safety

EURL heavy metals

IMEP-115: Determination of methylmercury in seafood by elemental mercury analysis: collaborative study, Cordeiro F, Calderon J, Gonçalves S, Lourenço MH, Robouch P, Emteborg H, Conneely P, Tumba-Tshilumba MF and de la Calle MB, 2014, *Journal of AOAC International*, 97(2), 593–597

Feed premix: a difficult matrix for the accurate determination of trace elements – the outcome of IMEP-114 and IMEP-36, Fiamegos Y, Cordeiro F, Robouch R, Emteborg H, Charoud-Got J, Omberg LG, Rodushkin I and de la Calle MB, 2014, *Food Additives and Contaminants: Part A*, 31(1), 63–72

Setting maximum limits for trace elements in baby food in European legislation: the outcome of International Measurement Evaluation programme-33, Cordeiro F, Baer I, Robouch P, Emteborg H, Can SZ, Krata A, Zampella M, Quetel CR, Hearn R and de la Calle B, 2013, *Food Additives and Contaminants: Part A*, 30(4), 678–686

EURL PAHs

Proficiency test results for PAH analysis are not method-dependent, Sykes M, Rose M, Holland J, Wenzl T, Kelly J and Anderson D, 2013, *Analytical Methods*, Vol. 5, pp. 5345–5350, doi:10.1039/c3ay40850g

EURL feed additives

Experimental design for in-house validation of a screening immunoassay kit. The case of a multiplex dipstick for *Fusarium* mycotoxins in cereals, Lattanzio VMT, von Holst C and Visconti A, 2013, *Anal Bioanal Chem*, 405(24):7773–7782

Standardization of NIR microscopy spectra obtained from inter-laboratory studies by using a standardization cell, Fernández Pierna JA, Boix A, Slowikowski B, von Holst C, Maute O, Han L, Amato G, de la Roza B, Pérez Marín D, Lilley G, Dardenne P and Baeten V, 2013, *Biotechnol. Agron. Soc. Environ.*, 17(4), 547–555

Multi-residue method for the detection of veterinary drugs in distillers grains by liquid chromatography–Orbitrap high resolution mass spectrometry, Kaklamanos G, Vincent U and von Holst C, *Journal of Chromatography A*, 2013, 1322, 38–48

Annual report 2012 of the European Reference Laboratory for Feed Additives (EURL-FA) Authorisation and Control, von Holst C, Bellorini S, Chedin M, De Smet M, Drooghmans M, Gonzalez de la Huebra MJ, Gorcsi A, Kaklamanos G, Kelti J, Mitić D, Pinto CM, Robouch P, Serano F, Vincent U and Ezerskis Z, 2013, *JRC85627*

EURL food contact materials

Development of a harmonised method for specific migration into the new simulant for dry foods established in Regulation 10/2011: Establishment of precision criteria from an EU interlaboratory comparison organised by the EURL- Food Contact Materials for the quantification from and migration into poly(2,6-diphenyl phenylene oxide), Beldi G, Jakubowska N, Peyches Bach A and Simoneau C, 2012, Publication Office of the European Union, Luxembourg, *JRC Scientific and Technical Report*, EUR 25680 EN

Time- and temperature-dependent migration studies of Irganox 1076 from plastics into foods and food simulants, Beldi G, Pastorelli S, Franchini F and Simoneau C, 2012, *Food Additives and*

Contaminants - Part A Chemistry, Analysis, Control, Exposure and Risk Assessment, 29(5), 836–845

Identification and quantification of migration of chemicals from plastics baby bottles used as substitutes for polycarbonate, Simoneau C, Van den Eede L and Valzacchi S, *Food Additives and Contaminants - Part A Chemistry, Analysis, Control, Exposure and Risk Assessment*, 2012, 29(3), 469–480

Allergens in food

Development of a real-time PCR method for the simultaneous detection of soya and lupin mitochondrial DNA as markers for the presence of allergens in processed food. Gomez Galan AM, Brohée M, de Andrade Silva E, van Hengel AJ and Chassaing H, 2011, *Food Chem*, 127, 834–841

Validation Procedures for Quantitative Food Allergen ELISA Methods: Community Guidance and Best Practices, Abbott M, Hayward S, Ross W, Godefroy SB, Ulberth F, Van Hengel AJ, Roberts J, Akiyama H, Popping B, Yeung JM, Wehling P, Taylor SL, Poms RE and Delahaut P, 2010, *J. AOAC Int.*, 93, 442–450

Monitoring radionuclides in the environment and food

Certification of the reference material IRMM-426 for radionuclides in dried bilberries, Wätjen U, Spasova Y and Vasile M, 2014, *Applied Radiation and Isotopes*, 87, 475–479, Pubsy 82725

Results of an EC laboratory comparison on 40K, 90Sr and 137Cs in dried bilberry powder, Meresova J and Wätjen U, 2014, *Applied Radiation and Isotopes*, 87, 443–446, Pubsy 82723

FACET

Development of a new modelling tool (FACET) to assess exposure to chemical migrants from food packaging, Oldring PKT, O'Mahony C, Dixon J, Vints M, Mehegan J, Dequatre C and Castle L, 2014, *Food Additives & Contaminants: Part A*, Vol. 31, No 3, 444–465, <http://dx.doi.org/10.1080/19440049.2013.862348>

Estimates of dietary exposure to bisphenol A (BPA) from light metal packaging using food consumption and packaging usage data: a refined deterministic approach and a fully probabilistic (FACET) approach, Oldring PKT, Castle L, O'Mahony C and Dixon J, 2014, *Food Additives & Contaminants: Part A*, Vol. 31, No 3, 466–489, <http://dx.doi.org/10.1080/19440049.2013.860240>

Correlation of foodstuffs with ethanol–water mixtures with regard to the solubility of migrants from food contact materials, Seiler A, Bach A, Driffeld M, Paseiro Losada P, Mercea P, Tosa V and Franz R, 2014, *Food Additives & Contaminants: Part A*, Vol. 31, No 3, 498–511, <http://dx.doi.org/10.1080/19440049.2014.880518>

Dissemination and implementation of the new food safety tool for exposure assessment - Flavourings, Additives and food Contact materials Exposure Tool (FACET), Simoneau C, 2013, Publications Office of the European Union, EUR 26472, *JRC87489*, ISBN 978-92-79-35272-0, ISSN 1831-9424, doi:10.2788/63643

Gluten

Validation Procedures for Quantitative Gluten ELISA Methods: AOAC Allergen Community Guidance and Best Practices, Koerner TB, Abbott M, Godefroy SB, Popping B, Yeung JM, Diaz-Amigo C, Roberts J, Taylor SL, Baumert JL, Ulberth F, Wehling P and Koehler P, 2013, *J. AOAC Int.*, 96, 1033–1040

2. Food security

Food security forecast 2030

Sustainable Food Security: An Emerging Research and Policy Agenda, Sonnino R, Maragues Faus A and Maggio A, 2014, *International Journal of Sociology of Agriculture and Food*, Vol. 21, No 1, pp. 173–188, ISSN 0798–1759

Monitoring agricultural resources for food security

Early detection of biomass production deficit hot-spots in semi-arid environment using FAPAR time series and a probabilistic approach, Meroni M, Fasbender D, Kayitakire F, Pini G, Rembold F, Urbano F and Verstraete MM, 2014, *Remote Sensing of Environment* 01/2014; 142: 57–68. doi:10.1016/j.rse.2013.11.012

Image time series processing for agriculture monitoring, Eerens H, Haesen D, Rembold F, Urbano F, Tote C and Bydekerke L, 2014, *Environmental Modelling and Software* 01/2014, 53:154–162, doi:10.1016/j.envsoft.2013.10.021

Using Low Resolution Satellite Imagery for Yield Prediction and Yield Anomaly Detection, Rembold F, Atzberger C, Savin I and Rojas O, 2013, *Remote sensing*, 04/2013, doi:10.3390/rs5041704

Mapping the Spatial Distribution of Winter Crops at Sub-Pixel Level Using AVHRR NDVI Time Series and Neural Nets, Atzberger C and Rembold F, *Remote Sensing*, 03/2013, 5(3):1335–1354, doi:10.3390/rs5031335

Building resilience for food and nutrition security — a long-term response to food crises

The challenges of index-based insurance for food security in developing countries, Gommers R and Kayitakire F, 2013, *Publications Office of the European Union*, doi:10.2788/713

Historical extension of operational NDVI products for livestock insurance in Kenya, Vrieling A, Meroni M, Shee A, Mude AG, Woodard J, de Bie K and Rembold F, 2014, *International Journal of Applied Earth Observation and Geoinformation*, Vol. 28, 238–251

Data management and analyses

DataM, data on agriculture, trade and models – A tool for flexible management, extension and integration of (model) databases, Hélaine S, Himics M, M'Barek R, Caivano A, 2013, *Publications Office of the European Union*, doi:10.2791/17240

Price volatility

Agricultural Commodity Price Volatility and Its Macroeconomic Determinants: A GARCH-MIDAS Approach (No JRC84138), Donmez A and Magrini E, 2013, *Institute for Prospective Technological Studies, Joint Research Centre, Luxembourg: Publications Office of the European Union*, ISBN 978-92-79-33245-6 (pdf), ISSN 1831-9424 (online), doi:10.2791/23669

Extent and possible causes of intrayear agricultural commodity price volatility, Ott H, 2013, *Agricultural Economics*, doi:10.1111/agec.12043

Fertilizer markets and their interplay with commodity and food prices, Ott H, 2013, *Institute for Prospective Technological Studies, Joint Research Centre, Luxembourg: Office for the Official Publications of the European Union*, ISBN 978-92-79-25526-7 (pdf), ISSN 1831-9424 (online), doi:10.2791/82136

Global Agriculture Repository & Africa Food Price Volatility Project, Bougay V and Donmez, A, 2013, *The International Conference on Agricultural Statistics (ICAS) VI*, 23–25 October 2013, Rio de Janeiro, Brazil

Pilot study for food price collection in Africa (work in progress) *Challenges in Food and Nutrition Security in global and local*

African perspectives, Donmez A, Bougay V and M'Barek R, 2013, *FOODSECURE international conference*, Addis Ababa, Ethiopia, 7–9 October 2013

Donmez A. 2014, *Food Market Prices Collection in Africa, Information for Meeting Africa's Agricultural Transformation and Food Security Goals (IMAAFS) Conference*, 1 3 October 2014, Addis Ababa, Ethiopia.

Food market developments and uncertainty in the longer run

Climate Impacts in Europe, The JRC PESETA II Project, Ciscar JC, Feyen L, Soria A, Lavalle C, Raes F, Perry M, Nemry F, Demirel H, Rozsai M, Dosio A, Donatelli M, Srivastava A, Fumagalli D, Niemeyer S, Shrestha S, Ciaian P, Himics M, Van Doorslaer B, Barrios S, Ibáñez N, Forzieri G, Rojas R, Bianchi A, Dowling P, Camia A, Libertà G, San Miguel J, de Rigo D, Caudullo G, Barredo JI, Paci D, Pycroft J, Saveyn B, Van Regemorter D, Revesz T, Vandyck T, Vrontisi Z, Baranzelli C, Vandecasteele I, Batista e Silva F and Ibarreta D, 2014, *EUR 26586EN*

CAPRI Long-term Climate Change Scenario Analysis: The AgMIP Approach, Witzke H-P, Ciaian P and Delincé J, 2014, *Publications Office of the European Union*, doi:10.2791/60495

Partial Stochastic Analysis with the European Commission's version of the AGLINK-COSIMO model, Burrell A and Nii-Naate Z, 2013, *Publications Office of the European Union*, doi:10.2791/87727

Commodity Market development in Europe – Outlook Workshop 2014, Proceedings, Suta C, Araujo Enciso RS, Fellmann T, Perez Dominguez I and Santini F, 2014, *Publications Office of the European Union*, doi:10.2791/669705

Prospects for EU agricultural markets and income 2014 2024, 2014, *European Commission, DG Agriculture and Rural Development* http://ec.europa.eu/agriculture/markets-and-prices/medium-term-outlook/2014/fullrep_en.pdf

Local Food Security / FoodSecure

Modelling Agri-Food Policy Impact at Farm-household Level in Developing Countries (FSSIM-Dev). Application to Sierra Leone, Kamel Louhichi, Sergio Gomez y Paloma, Hatem Belhouchette, Thomas Allen, Jacques Fabre, María Blanco Fonseca, Roza Chenoune, Szvetlana Acs and Guillermo Flichman, 2013 *JRC Scientific and Policy Reports*, EUR 25962 EN

<http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=6400>.

A farm household model for agri-food policy analysis in developing countries: application to smallholder farmers in Sierra Leone, Food Policy, V. 45, April 2014, Pages 1 13. Louhichi K., Gomez y Paloma S. <http://www.sciencedirect.com/science/article/pii/S0306919213001607>

Assessing the FNS impacts of technological and institutional innovations and future innovation trends; Pangaribowo E (ZEF-UBO), Gerber N (ZEF-UBO), Tillie P (JRC), 2013, *FOODSECURE Working paper no 11*, <http://www3.lei.wur.nl/FoodSecurePublications/FoodSecure-WP-11n.pdf>

Conceptual framework on price volatility and its impact on food and nutrition security in the short term, Kalkuhl M (ZEF), Kornher L (ZEF), Kozicka M (ZEF), Boulanger P (JRC), Torero M (IFPRI), 2013, *FOODSECURE Working Paper no 15*, http://www3.lei.wur.nl/FoodSecurePublications/15_Kalkuhl_conceptualFramework-PriceVolatilityFNS.pdf

Fisheries and aquaculture

The 2014 Annual Economic Report on the EU Fishing Fleet (STECF 14-16). Scientific, Technical and Economic Committee for Fisheries (STECF). Paulrud A., Dentes de Carvalho Caspar, N.; Borrello, A. (2014). *Scientific and Policy Report JRC92507*

Genetic identification in support of fisheries management: Principles and context. Martinsohn J, Carvalho G. *Genetic identifica-*

tion in support of fisheries management: Principles and context. In: Johanne Fischer, editor. *FAO report on Fish Identification Tools for Biodiversity and Fisheries Assessments*. Rome (Italy): Food and Agriculture organization of the United Nations; 2014. p. 57-67. JRC85412

Modelling of the European hake nurseries in the Mediterranean sea: An ecological niche approach. Druon J, Fiorentino F, Murenu M, Knittweis L, Colloca F, Osio G, Merigot B, Garofalo G, Mannini A, Jadaud A, Sbrana M, Scarcella G, Tserpes G, Peristeraki P, Carlucci R, Heikkonen J. *Progress in Oceanography* 130; 2015. p. 188-204. JRC90269

A medium-term, stochastic forecast model to support sustainable, mixed fisheries management in the Mediterranean Sea. Raetz H, Charef A, Abella A, Colloca F, Ligas A, Mannini A, Lloret J. *Journal of Fish Biology* 83 (4); 2013. p. 921-938. JRC70877

Interactions between Aquaculture and Fisheries. Natale F, Hofherr J, Fiore G, Virtanen J. *Marine Policy* 38; 2013. p. 205-213. JRC70119

European Aquaculture Performance Indicators - Indicators for Sustainable Aquaculture in the European Union. HOFHERR J., NATALE F., FIORE G. JRC75891

Identifying fisheries dependent communities in EU coastal areas. Natale F, Dentes De Carvalho Gaspar N, Harrop M, Guillen J, Frangoudes K. *Marine Policy* 42; 2013. p. 245-252. JRC74191

3. Agriculture and land use

Agricultural monitoring and forecasting

Campaign Review, Baruth B, Biavetti I, Bussay A, Ceglar A, Chukaliev O, Duveiller G, Fontana G, Karetsos S, Lecerf R, Lopez-Lozano R, Seguni L, Srivastava AK, Van den Berg M, 2013, MARS Bulletin Vol. 21 No 13, Publications Office of the European Union, ISSN 2314-9736, JRC24736

QUAMP2. A Quality Assessment Tool for the MARS Crop Yield Forecasting System, Gallego Pinilla F and van der Wijngaart R, 2013, European Commission, Joint Research Centre, JRC87543

Efficiency assessment of using satellite data for crop area estimation in Ukraine, Gallego Pinilla F, Kussul N, Skakun S, Kravchenko O, Shelestov A, Kussul O, 2014, *International Journal of Applied Earth Observation and Geoinformation*, Vol 29, pp. 22-30, doi:10.1016/j.jag.2013.12.013

An auto-calibration procedure for empirical solar radiation models, Bojanowski J, Donatelli M, Skidmore A, Vrieling A, 2013, *Environmental Modelling and Software*, Vol. 49, pp. 118-128, doi:10.1016/j.envsoft.2013.08.002

A regional implementation of WOFOST for calculating yield gaps of autumn-sown wheat across the European Union, Boogard H, Wolf J, Supit I, Niemeyer S, Van Ittersum M, 2013, *Field Crops Research*, Vol. 142, pp. 130-142, doi:10.1016/j.fcr.2012.11.00

Enhanced Processing of 1-km Spatial Resolution fAPAR Time Series for Sugarcane Yield Forecasting and Monitoring, Duveiller G, Lopez-Lozano R, Baruth B, 2013, *Remote Sensing*, Vol. 5, pp. 1091-1116, doi:10.3390/rs5031091

New biological model to manage the impact of climate warming on maize corn borers, Maiorano A, Cerrani I, Fumagalli D, Donatelli M, 2013, *Agronomy for Sustainable Development*, doi:10.1007/s13593-013-0185-2

Bioeconomy

Observing and analysing the Bioeconomy in the EU - Adapting data and tools to new questions and challenges, M'barek R, Philippidis G, Suta C, Vinyes C, Caivano A, Ferrari E, Ronzon T, Sanjuan LA and Santini F, 2014, *Bio-based and Applied Economics* 3(1): 83-91

Employing social accounting matrix multipliers to profile the Bio-Economy in the EU Member States: Is there a strategic pattern, Philippidis G, Sanjuán AI, Ferrari E and M'barek R, 2014, *Spanish Journal of Agricultural Research*, v. 12, n. 4, pp. 913-

926, ISSN 2171-9292

Evaluating the macro-economic impacts of biobased technologies in the EU, Smeets E, Vinyes C, Tabeau A and Van Meijl H, 2014, Report EUR 26777 EN, ISBN 9789279395369

Soil

Land take and food security: assessment of land take on the agricultural production in Europe, Gardi C, Panagos P, Van Liedekerke M, Bosco C, De Brogniez D, 2014, *Journal of Environmental Planning and Management* 05/2014

Modelling support for the Common Agricultural Policy

Farm-level models for EU policy analysis: review of recent literature and comparison of most relevant models, Louhichi K., Espinosa M., Ciaian P. and Gomez y Paloma S., 2013, In: *Farm Level Modelling of CAP: a methodological overview*. JRC Scientific and Policy Reports, EUR 25873 EN, Luxembourg: Publications Office of the European Union, 2013. ISBN: 978-92-79-29012-1. 84 p., <http://ftp.jrc.es/EURdoc/JRC79969.pdf>;

Marianne Lefebvre, Kim De Cuyper, Ellen Loix, Davide Viaggi, Sergio Gomez y Paloma, European farmers' intentions to invest in 2014-2020: survey results, (2014) JRC Science and Policy Reports, EUR 26672 EN, <http://bookshop.europa.eu/en/european-farmers-intentions-to-invest-in-2014-2020-pbLFNA26672/?catalogCategoryID=aLoKABstwUAAAAEjqpEY4e5L>

Farm Type Effects of an EU-wide Direct Payment Harmonisation, Gocht, A., W. Britz, P. Ciaian, S. Gomez y Paloma, 2013, *Journal of Agricultural Economics* 64(1), pp. 1-32, <http://onlinelibrary.wiley.com/doi/10.1111/1477-9552.12005/abstract>;

Modelling the Common Agricultural Policy with the Modular Agricultural GeNeral Equilibrium Tool (MAGNET). Effects of the 2014-2020 CAP financial agreement on welfare, trade, factor and product markets, 2014, Luxembourg: Publications Office of the European Union, ISBN 978-92-79-40331-6, doi:10.2791/12628

Agricultural landscapes as multiscale public good and the role of the Common Agricultural Policy, Lefebvre M, Espinosa M, Gomez y Paloma S, Paracchini ML, Pierra and Zasada I, 2014, *Journal of Environmental Planning and Management*, ahead-of-print (2014): 1-25, <http://dx.doi.org/10.1080/09640568.2014.891975>

The future of agriculture. Prospective scenarios and modelling approaches for policy analysis, Gomez y Paloma S, Ciaian P, Cristoiu A and Sammeth F, 2013, *Land Use Policy* (Reference number: LUP-D-11-00112), Vol. 31, March, pp. 102-113, <http://www.sciencedirect.com/science/article/pii/S0264837711001517>

CAP land use

EU sugar policy: A sweet transition after 2015?, Burrell A, Himics M, Van Doorslaer B, Ciaian, P, Shrestha, S, 2014, Publications Office of the European Union, doi:10.2791/68116

Impacts of the EU biofuel policy on agricultural markets and land use, Hélaine S, M'barek R and Gay H, 2013, Publications Office of the European Union, doi:10.2791/20985

On the asynchronous approvals of GM crops: Potential market impacts of a trade disruption of EU soy imports, Henseler M, Piot-Lepetit I, Ferrari E, Gonzalez Mellado A, Banse M, Grethe H, Parisi C and Hélaine S, 2013, *Food Policy*, (41), pp. 166-176, <http://dx.doi.org/10.1016/j.foodpol.2013.05.005>

Methodology to assess EU Biofuel Policies: The CAPRI Approach, Blanco M, Adenauer M, Shrestha S and Becker A, 2013, Publications Office of the European Union, doi:10.2791/82235

Greenhouse gas emissions and biofuel policies impacting the agricultural sector

EU sugar policy: A sweet transition after 2015?, Burrell A, Himics

M, Van Doorslaer B, Ciaian P and Shrestha S, 2014, Publications Office of the European Union, doi:10.2791/68116.

Impacts of the EU biofuel policy on agricultural markets and land use, Hélaïne S, M'barek R, Gay H, 2013, Publications Office of the European Union, doi:10.2791/20985.

On the asynchronous approvals of GM crops: Potential market impacts of a trade disruption of EU soy imports, Henseler M, Piot-Lepetit I, Ferrari E, Gonzalez Mellado A, Banse M, Grethe H, Parisi C and Hélaïne S, 2013, Food Policy, (41), pp. 166–176, <http://dx.doi.org/10.1016/j.foodpol.2013.05.005>

Methodology to assess EU Biofuel Policies: The CAPRI Approach, Blanco M, Adenäuer M, Shrestha S, Becker A, 2013, Publications Office of the European Union, doi:10.2791/82235

ILUC

Progress in estimates of ILUC with MIRAGE model, Laborde D, Padella M, Edwards R, Marelli L, 2014, Luxembourg: Publications Office of the European Union, ISBN 978-92-79-32552-6. doi:10.2790/92998

Impacts of the EU biofuel policy on agricultural markets and land use. Modelling assessment with AGLINK-COSIMO, Hélaïne S, M'barek R and Gay H, 2013, Luxembourg: Publications Office of the European Union, ISBN 978-92-79-32649-3, doi:10.2791/20985

Promoting environmental sustainability in the food supply chain

Harald Schoenberger, Paolo Canfora, Marco Dri, Jose Luis Galvez-Martos, David Styles, Ioannis Sofoklis Antonopoulos. Development of the EMAS Sectoral Reference Documents on Best Environmental Management Practice. JRC Scientific and Policy Report, 2014. ISBN 978-92-79-34532-6

Harald Schoenberger, Jose Luis Galvez-Martos, David Styles. Best environmental management practice in the retail trade sector. JRC Scientific and Policy Report, 2013. ISBN 978-92-79-30495-8

4. Food quality

Review on metabolomics for food authentication, Cubero-Leon E, Peñalver R and Maquet A, 2014, Food Research International Food Research International 2014, 60, 95–107

The European Coexistence Bureau: Five Years' Experience, Rizov I and Rodriguez-Cerezo E, 2014, AgBioForum, 17(1): 1-6

Best Practice Documents for monitoring efficiency of coexistence measures in maize crop production, Rizov I. and Rodriguez-Cerezo E, 2014, EUR 26261 EN, ISBN 978-92-79-34480-0

Best Practice Documents for coexistence of GM maize and honey production, Rizov I and Rodriguez-Cerezo E, 2013, EUR 26041 EN, ISBN 978-92-79-31483-4

5. Food for health

Mapping of School Food Policies across the EU-28 plus Norway and Switzerland, Storcksdieck genannt Bonsmann S, Kardakis T, Wollgast J, Nelson M, Caldeira S, 2014, JRC Science and Policy Report, doi:10.2788/8214

Assessing school food policies across the EU-28 plus Norway and Switzerland, Storcksdieck genannt Bonsmann S, Wollgast J, Caldeira S, 2014, Appetite 76, pp. 197–215. doi:10.1016/j.appet.2014.01.020

Countering obesity by combining behavioral insights and novel ICT tools: a workshop report, European Commission, 2013, doi:10.2788/86884

Trans fatty acids in the EU: where do we stand?, Mouratidou T, Saborido CM, Wollgast J, Livaniou A and Caldeira S, 2014, JRC

Scientific and Policy Reports

Trans Fatty Acids in Diets: Health and Legislative Implications, Mouratidou T, Saborido CM, Wollgast J, Ulberth U, Caldeira S, 2013, doi:10.2788/31567

JRC Foresight study Tomorrow's healthy society – Research priorities for foods and diets, Bock AK, Maragkoudakis P, Wollgast J, Caldeira S, Czimbalmos A, Rzychon M, Atzel B, Ulberth F, 2014, JRC Science and Policy Report, EUR 26821 EN

6. Fostering the innovation flow

Nanotechnology

Towards a review of the EC Recommendation for a definition of the term 'nanomaterial'; Part 1: Compilation of information concerning the experience with the definition, Rauscher H, Roebben G, Amenta V, Boix Sanfeliu A, Calzolai L, Emons H, Gaillard C, Gibson N, Linsinger T, Mech A, Quiros Pseudo L, Rasmussen K, Riego Sintés J, Sokull-Klüttgen B, Stamm H, 2014, JRC Scientific and Policy Report, (EUR 26567 EN)

Towards a review of the EC Recommendation for a definition of the term 'nanomaterial'; Part 2: Assessment of information concerning the experience with the definition, Roebben G, Rauscher H, Amenta V, Boix Sanfeliu A, Calzolai L, Emons H, Gaillard C, Gibson N, Holzwarth U, Koeber R, Linsinger T, Rasmussen K, Sokull-Klüttgen B, Stamm H, 2014, JRC Scientific and Policy Report, (EUR 26744 EN)

Considerations on information needs for nanomaterials in consumer products. Discussion of a labelling and reporting scheme for nanomaterials in consumer products in the EU, Aschberger K, Rauscher H, Crutzen H, Rasmussen K, Christensen FM, Sokull-Klüttgen B, Stamm H, 2014, JRC Scientific and Policy Report, (EUR 26560 EN)

The European Commission's Recommendation on the Definition of Nanomaterial Makes an Impact, Rauscher H, Sokull-Klüttgen B and Stamm H, 2013, Nanotoxicology, 7(7): 1195–1197, doi:10.3109/17435390.2012.724724

Reference materials and representative test materials: the nanotechnology case, 2013, Roebben G, Rasmussen K, Kestens V, Linsinger TPJ, Rauscher H, Emons H and Stamm H, J Nanopart. Res., 15.3 (2013) 1–13

Proceedings of a workshop on "Nanotechnology for the agricultural sector: from research to the field", edited by Parisi C, Vigani M, Rodríguez-Cerezo E, 2014, JRC Scientific and Policy Report, EUR 26625 EN

Agricultural Nanotechnologies: What are the current possibilities? Parisi C, Vigani M, Rodríguez-Cerezo E, 2014, Nano Today, doi:10.1016/j.nantod.2014.09.009

New Plant Breeding Techniques

Comparative regulatory approaches for groups of new plant breeding techniques, Lusser M, Davies HV, 2013, New Biotechnology, 30(5): 437–446, ISSN 1871-6784

The JRC works in close contact with a vast array of institutions, research networks and science-led public and private partners, and is continuously strengthening cooperation on global issues with international partners and organisations.

In the food field, worldwide cooperation for safety standards involves collaboration with universities; Member States control laboratories, NRLs, international organisations, agencies, health and agricultural ministries, authorities, international representatives from research and safety organisations and regulators. A representative sample of these partners is shown here.

European Commission
Joint Research Centre
Luxembourg: Publications Office of the European Union, 2015

2015 – 40pp. – 21.0 x 29.7cm

EUR – Scientific and Technical Research Series

ISBN 978-92-79-46015-9 (pdf)
ISBN 978-92-79-46013-5 (print)
doi: 10.2760/603998 (online)

Picture credits

All images copyright European Union except:

Cover page: ©Monkey Business - Fotolia.com
Pages 2 and 3: ©Eisenhans - Fotolia.com
Page 4 introduction banner ©Monika Wisniewska - Fotolia.com
Pages 4 and 6: essay tubes ©djama - Fotolia.com
Pages 5 and 21: landscape ©Gudellaphoto - Fotolia.com
Pages 5 and 25: Olive oil ©hiphoto39 - Fotolia.com
Pages 5 and 28: fruits and vegetables ©millefloreimages - Fotolia.com
Page 8: ©Ignatius Wooster - Fotolia.com
Page 16: ©Africa - Fotolia.com
Page 19: ©Christian Delbert - Fotolia.com
Page 20 : ©Goran Bogicevic - Fotolia.com
Page 23: ©Dusan Kostic Fotolia.com - Fotolia.com
Page 25: shopping cart ©Eisenhans - Fotolia.com
Page 31: ©taraki - Fotolia.com

Abstract

This report provides a detailed overview of Joint Research Centre (JRC) research on food safety, food quality and authenticity, food security, agriculture and land use, food for health, and innovation in this area as the European Commission's in-house science service.

JRC Mission

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners.

*Serving society
Stimulating innovation
Supporting legislation*

