New Food | IN-DEPTH FOCUS

# Food Safety

Dr Simona Birtic explains how rosemary can offer an effective natural solution to the preservation of meat

Following Food Integrity 2021, Liz Colebrook from Mars Inc recaps on some of the key insights gleaned from the conference

UCD's Professor Da-Wen Sun and Xiaohui Lin explore the use of hyperspectral imaging as an alternative tool for rapid analysis

Questions about olive oil? Read the first of a two-part article written by members of the OLEUM Project

# A botanical-based approach to keeping meat safe and fresh

**While many traditional means of preserving meat are no longer acceptable to today's consumers, rosemary can provide an effective natural solution.**

**Dr Simona Birtic**

Simona holds a PhD in seed biochemistry and molecular biology. She joined Naturex in 2013 as a Plant Antioxidants Scientist and is now the Category Technical Leader for Food Preservation at Givaudan, where her research focuses on the role of plant antioxidants and antimicrobials in food matrices.

FOR THE MEAT and poultry industry, maintaining product quality throughout the shelf life is vital.

Meat is susceptible to both microbial contamination, which can cause illness and negatively impact taste and oxidative degradation, consequently influencing flavour, smell and colour.

While manufacturers might have previously relied on stringent processing conditions or the use of artificial preservatives to protect their products, these approaches have significant drawbacks.

Processing techniques such as heat inactivation result in reduced freshness and quality, impaired taste and texture, and loss of natural nutrients.

Antimicrobials such as sodium lactate, sodium acetate and nitrites, meanwhile, are incompatible with the back-to-basics and clean-label trends.

Seven out of 10 consumers worldwide now believe it's important that food and drink products are 100 percent natural, while 62 percent have concerns over ingredients that "sound chemical".[1]

Rosemary can resolve this dilemma for manufacturers by providing a clean preservation solution thanks to its antimicrobial and antioxidative properties, which are conferred by the plant's active compounds.

## The importance of food safety

Every year, around 600 million people fall ill as a result of contaminated food.[2] As such, it is perhaps unsurprising that the International Food Information Council's 2020 Food & Health Survey shows foodborne illness from bacteria remains the most widespread food safety issue for consumers, with more than half of respondents naming it among their top three concerns.[3]

Recent research by the UK's Food Standards Agency (FSA) found that *Salmonella* and *Listeria* are two of the most widely known causes of food poisoning, recognised by 92 and 61 percent of consumers respectively.[4]

According to the World Health Organization (WHO), annual cases of foodborne listeriosis caused by *Listeria monocytogenes* vary between 0.1 and 10 per million people across different parts of the world. High-risk foods include deli meat and cooked, cured and/or fermented meats and sausages.[5]

*Salmonella* is one of four key causes of diarrhoeal diseases worldwide. Salmonellosis in humans is generally contracted through the consumption of contaminated food of animal origin, including meat and poultry.[6]

## Rosemary's antimicrobial action

The food industry is now developing an increased understanding of rosemary's ability to provide a

clean-label solution to microbial contamination. While it has been known for many years that the plant can be used to protect against certain microbes, it was previously thought that this was purely due to its essential oils.

However, we now know that rosemary extracts rich in a phenolic diterpene (called carnosic acid) can prevent the growth of a range of bacteria commonly found in meat and poultry, including *Listeria* and *Salmonella*.[7]

Givaudan tested more than 200 botanical products against a range of bacteria, yeasts and moulds to establish which were most active. The extracts were assessed according to their Minimal Bactericidal Concentration (MBC) and Minimum Fungicidal Concentration (MFC).

The research revealed that rosemary was one of the most effective – particularly when the extracts were abundant in carnosic acid. In fact, rosemary was shown to be active against 11 of 14 microbial species, even at fairly low concentrations.

## Natural antioxidative qualities

The lipid content in meat and poultry products also leaves them susceptible to spoilage in the form of oxidation. While oxidation may not necessarily pose a health risk for the consumer, it does lead to unpleasant smells and flavours as well as colour fading.[8,9]

Rosemary is rich in various active components and is thought to be the most abundant natural source of carnosic acid, which is also known to be a highly potent antioxidant.[10]

Antioxidants work to prevent lipid oxidation by various mechanisms, including controlling oxidation substrates (lipids and oxygen) and pro-oxidants (chemicals that induce oxidative stress) as well as inactivating free radicals.[11]

As a result of the plant's antioxidation properties, rosemary extracts have been shown to limit the degradation that occurs when food and drink products are exposed to oxidation catalysts such as oxygen, light and temperature.[12]

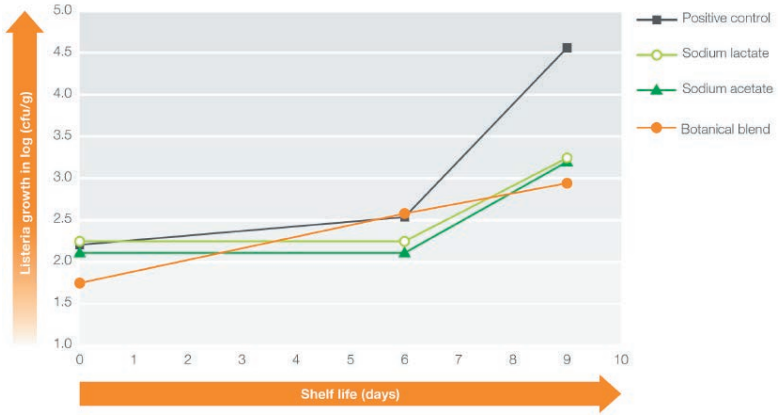
Rosemary's active compounds have now earned widespread recognition as an effective means of preserving food's freshness, taste and colour, and the plant is being used increasingly widely as a natural alternative to synthetic antioxidants across many processed food categories.

Indeed, between 2008 and 2019, the number of product launches featuring 'rosemary extract' on the label increased more than seven-fold globally.[13]

## Synergistic solutions

Our increased knowledge about rosemary's antimicrobial and antioxidative powers affords huge scope for innovation by combining its strengths with those of other botanical extracts.

**Figure 1**




*Listeria* growth reduction in fresh ground meat

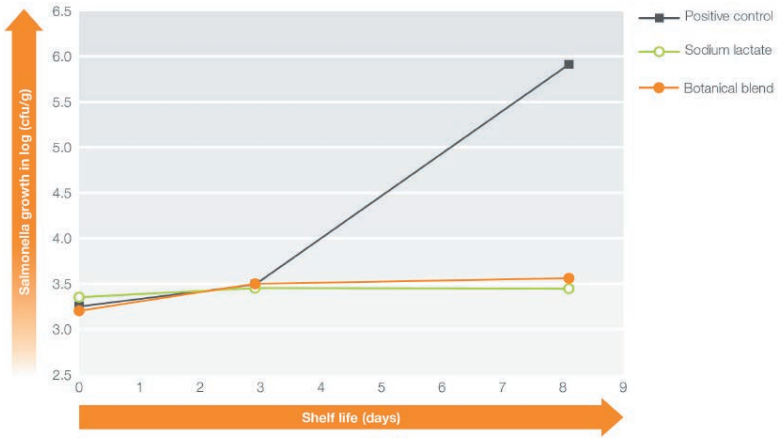
Uniting the attributes of different plant sources can open up superior preservation possibilities using natural, well-known ingredients such as acerola, green tea or pomegranate.

A blend of rosemary extract and citrus extract, for example, can enhance the antilisterial effect in meat and poultry products.

In a laboratory study conducted by Givaudan, researchers inoculated four samples of fresh ground beef with *Listeria monocytogenes* (3 log). The researchers compared the effects of the blend at 0.4 percent to two conventional preservatives – sodium acetate at 0.3 percent and sodium lactate at 2.5 percent – and a control sample with no antimicrobial agent.

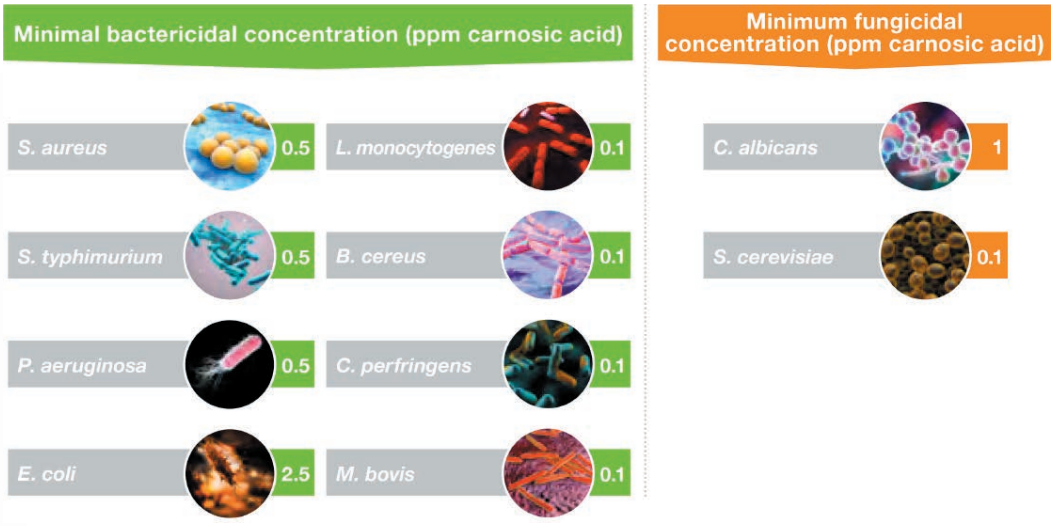
The beef was stored at 8°C for nine days. At the end of the study, the blend provided better than 1.5 log reduction in *Listeria* growth compared with the control – a greater reduction than conventional preservatives achieved.

**Figure 2**




*Salmonella* growth reduction in fresh ground meat

**Figure 3**




The MBC and MFC of rosemary (*R. officinalis*) extract

Thanks to rosemary's antioxidative properties, there was also no deterioration in the fresh taste or odour of the meat in the sample containing the blend, while the red colour of the product was retained. The same tests were performed on fresh pork sausages with comparable results.

A combination of rosemary extract, acerola cherry powder and buffered vinegar has also proven to be highly effective against *Salmonella*.

A further laboratory study conducted by Givaudan showed that in fresh ground meat inoculated with *Salmonella typhimurium*, the blend at 0.4 percent delivered a greater than 2 log reduction in *Salmonella* growth compared with the control sample.

Over the course of nine days at 8°C, the protection was similar to that provided by sodium lactate at 2.5 percent. As with the rosemary and citrus blend, there was no deterioration in the fresh taste or odour of the meat and the product's red colour was retained.

These results show that meat processors can now utilise rosemary blends to achieve natural antimicrobial and antioxidant effects, safe in the knowledge that consumer safety is assured and product quality maintained.

EXPERT VIEW

**Cristina Romero Gonzalo**
Product Manager for Food Allergen Testing, Eurofins Technologies

eurofins | Technologies

For further information, visit:
**eurofins-technologies.com**

# A rapid and easy-to-use tool for on-site gluten testing

**Cristina Romero Gonzalo explains the need for reliable on-site gluten testing, highlighting a new solution from Eurofins Technologies.**

Coeliac disease is a permanent auto-immune disorder that occurs in people with a genetic predisposition for the disease. It causes the ingestion of gluten to damage the small intestine mucosa, preventing the absorption of micro and macronutrients.

As the only treatment for coeliac disease symptoms is the elimination of gluten from the diet, it is crucial that the food industry, when marking a product as gluten-free, can reliably claim that the product does not contain this allergen.

To ensure this, the food industry must have adequate tools at their disposal to monitor the whole process quickly and reliably.

The **SENSIStrip Gluten kit** is a new Lateral Flow Device for the detection of gluten in food, and environmental and rinse water samples, designed to meet the industry's needs.

The high sensitivity values of the assay for different matrices assures a high level of confidence when performing the screening at different sites of manufacturing facilities and offers a quick tool to detect gluten contamination risk during food processing. This method considerably reduces the time taken to release a food product batch to market.

All necessary materials to perform the testing are provided in the kit, including an evaluation card for interpreting the results in a semi-quantitative way. A validated standalone reader is also available for the most accurate result interpretation.

The use of this kind of rapid testing tool is necessary to assess the risk of gluten contamination during the manufacturing process and to reassure affected people that they can safely consume the products which are marked gluten-free.

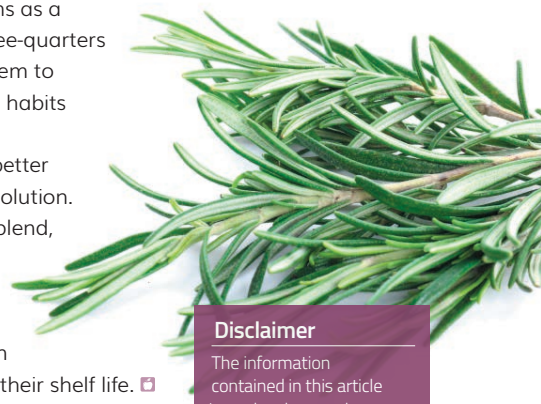
## The natural choice

In the past, meat processors have had little option but to compromise their products' clean-label credentials to keep them safe and fresh, but such solutions are increasingly unacceptable to consumers.

The 2020 Food & Health Survey, for example, found that today's shoppers see products as healthier when they are labelled 'all natural' and contain no artificial additives.[14]

Since the pandemic, consumers have also been paying even more attention to the food they eat. Fifty-six percent worldwide say they are more attentive to natural ingredient claims as a result of COVID-19,[15] and nearly three-quarters (73 percent) have said it will lead them to adopt healthier eating and drinking habits going forwards.[16]

As such, there has never been a better time to use a natural preservation solution. Whether on its own or as part of a blend, rosemary can provide an effective antimicrobial and antioxidative solution of natural origin to help meat and poultry products maintain their safety and quality throughout their shelf life.



### Disclaimer

The information contained in this article is not legal or regulatory advice, or otherwise a recommendation to the recipient and should not be relied on as such. The recipient is solely and exclusively responsible for conducting its own regulatory and legal evaluation on its consumer facing product labelling and packaging, including all claims the recipient makes as well as how the recipient decides to identify and disclose ingredients on product consumer-facing labels.

### References


1. FMCG Gurus 'The Future of Naturalness 2020' (August 2020)
2. World Health Organization 'Food safety' (April 2020)
3. International Food Information Council '2020 Food & Health Survey'
4. Food Standards Agency 'Public attitudes tracker' (2019)
5. World Health Organization 'Listeriosis' (February 2018)
6. World Health Organization 'Salmonella (non-typhoidal)' (February 2018)
7. Birtic S, et al. 'Carnosic acid' Phytochemistry (2015)
8. Wasowicz E, *et al.* 'Oxidation of lipids in food' Polish Journal of Food and Nutrition Sciences (2004)
9. Embuscado ME. 'Herbs and spices as antioxidants for food preservation' Handbook of Antioxidants for Food Preservation (2015)
10. Birtic S, et al. 'Carnosic acid' Phytochemistry (2015)
11. Wasowicz E, *et al.* 'Oxidation of lipids in food' Polish Journal of Food and Nutrition Sciences (2004)
12. Loussouarn M, et al. 'Carnosic Acid and Carnosol, Two Major Antioxidants of Rosemary, Act through Different Mechanisms' Plant Physiology (2017)
13. Mintel GNPD
14. International Food Information Council '2020 Food & Health Survey'
15. FMCG Gurus 'COVID-19' (July 2020)
16. FMCG GURUS 'Evaluating the Uncertainty & Future Outlook of COVID-19' (April 2020)


# Food integrity in the global supply chain

**Sharing exclusive insights gleaned from Food Integrity 2021, Liz Colebrook from Mars Incorporated reflects on the role that regulation plays on the international food safety stage.**

*"More than 3.5 billion people depend on rice for as much as one fifth of their daily calories"*

I WAS PRIVILEGED to take part in a panel discussion at this year's Food Integrity 2021 Event, hosted by *New Food*. The topic of discussion was *Regulating to Increase Integrity*, and my co-panellists were Caitlin Boon, Associate Commissioner for Food Policy and Response at the United States Food and Drug Administration (FDA), and Peter Whelan, Director of Audit and Investigations, Food Safety Authority of Ireland. The session was facilitated by Michael Bell, Executive Director Northern Ireland Food and Drink Association. Reflecting on the session, a few topics stood out.

## Ethics and trust are paramount in regulation

We began by considering what integrity means; being honest and having moral principles perhaps? I like the quote from C S Lewis that, "Integrity is doing the right thing when no one is looking" as I feel this is particularly apt for the food industry. While scrutiny of industry's activities has increased over the past decade, it simply isn't possible for enforcement authorities to be present at every manufacturing plant or retail outlet. There must, therefore, be a degree of trust that the same high standards will be maintained whether or not 'someone is looking'. Most importantly, consumers

must be able to trust that industry is 'doing the right thing when no one is looking', and to that end, industry must be able to demonstrate support of appropriate regulation and adherence to it.

In many countries, including the UK, US and Australia, there are already regulations in place that prohibit the misrepresentation of food. The difficulty is that with ever-improving testing and detection methods increasing our ability to spot low levels of potential contaminants, alongside global food supply chains and e-commerce, the task of defining food authenticity is complex and likely to become even more so in the future.

## Monitoring the impact of emerging technology on recent regulatory decisions

We also discussed the four core elements of the Food and Drug Administration's 'New Era of Smarter Food Safety Blueprint', published in July 2020. These elements comprise technology-enabled traceability, smarter tools and approaches for prevention and outbreak response, new business models and retail modernisation, and supporting a food safety culture. These foundational pillars cover a range of technologies, analytics, business models, modernisation and values considered by those on the panel to be the building blocks of the future of food safety regulation. The panel anticipated that these elements combined will help create a safer and more digital, traceable food system.

One of the tools used to help demonstrate compliance with regulation, as well as the authenticity of food, is testing – whether that be microbiological, testing for adulteration, or simply conformity with product specifications. Nevertheless, regulation and testing cannot exist in isolation – regulation without testing is not enforceable and testing without regulation is toothless. As technology advances, portable testing solutions could prove to be game changers for the industry – already there are drones that can be used to monitor the status of crops. However, for technology to be truly impactful it needs to not only be portable but also reliable and affordable.

It was interesting to hear the perspective of the FDA on Whole Genome Sequencing (WGS), which has been revolutionary in many ways, including detecting food fraud such as species substitution in crabmeat. The Mars Global Food Safety Center is also interested in this area, and has published several scientific papers on the subject of WGS. Overall, utilising a wide variety of technologies is seen as the best way to progress in combatting food fraud. Artificial Intelligence (AI) is currently being trialled in the USA to confirm the authenticity of imported seafood and significant improvements have been achieved in targeting suspect shipments for examination.

Protecting the rice supply chain is vital due to the number of people that rely on it as a major part of their diet

More than 3.5 billion people depend on rice for as much as one fifth of their daily calories,[1] with Asia accounting for 90 percent of global rice consumption, so protecting that supply chain is essential. In rice adulteration, authentic rice may be mixed with low grade, low quality rice for economic gain, or even have fake or plastic rice grains mixed in to bulk out the volume. It is important, therefore, to develop robust methods to ensure rice authenticity, helping to protect both consumers and the reputations and brands of legitimate suppliers. In 2020, the Mars Global Food Safety Center (GFSC) completed an international collaboration project tackling rice adulteration. Together with selected research partners, including Queen's University Belfast (QUB) and Agilent Technologies, the team successfully developed a two-tier testing programme, capable of rapidly screening the geographical origins of rice within the supply chain.

Examples such as these are the technological 'big wins' that attract a lot of media attention and help to progress the prevention of fraudulent activities via inspection. However, equally important, but perhaps less visible, are the activities of the people representing audit and regulatory bodies responsible for exposing fraudulent activities when they take place. It would be a »

*"To successfully combat food fraud, there must be proportionate and well-constructed regulation that does not represent a barrier to trade"*

*"A global, collaborative mindset is what will help pull millions of people back from the brink of starvation"*

**Liz Colebrook**

Liz is Global Scientific and Regulatory Affairs Director of Food Safety at Mars, Incorporated. Liz has more than 35 years' experience in food safety science and regulatory affairs, and graduated in Food Science at Reading University, beginning her food industry career in technical auditing and product development. After entering the world of regulatory affairs during her employment with H J Heinz, Liz joined Mars Petcare as a Legal and Regulatory Affairs Manager in 2001. During her 20 years with Mars, Liz has predominantly worked in the Scientific and Regulatory Affairs arena, completing a Masters in European Food Regulatory Affairs in 2003. In her current role, she is responsible for food safety horizon scanning as well as the development of leadership strategy, knowledge and insights relating to food safety regulation.

mistake to think that food fraud is something that happens 'somewhere else' and is committed by 'someone else' – examples have been detected of such activities in the UK, often using sophisticated methods to avoid detection, and those who painstakingly track the actions of these criminals are to be applauded.

## Regulating to prevent food fraud

Although the typical high value commodities such as honey, seafood, olive oil, and herbs and spices associated with food fraud were cited by the panel, it was also pointed out that local cases of food fraud, in a particular country or region, may be less obvious, but do occur. Such instances include poachers that steal one or two sheep, butcher them in unlicensed and uninspected premises, and then sell the meat cheaply from the back of a car, in a local pub, or even launder it into the food chain.

The last 20 years has borne witness to various transitions in consumer trends. Focus has shifted from taste, to nutrition, to safety, and now the issue of integrity and authenticity, while still demanding convenience and value. Juxtaposed with these consumer aspirations are the pressures placed on industry to produce affordable, safe, nutritious food, while implementing greater controls and checks than ever before. These two, apparently conflicting, perspectives also highlight another facet of food fraud, which is that those most at risk of falling foul of food fraud are those who struggle to afford even the daily basics. Even in countries where food integrity is often taken for granted, such as the UK, divisions have grown between those whose biggest problem is their favourite item not being on the supermarket shelf, and those who don't know where their next meal is coming from. In regions where the food chain is more unstable, the recent pandemic has given rise to greater opportunities for adulteration and other frauds.

To successfully combat food fraud, there must be proportionate and well-constructed regulation that does not represent a barrier to trade; this can take time to develop, which may conflict with the pace of development, both in new manufacturing technologies and detection techniques. Nonetheless, it's important that regulation is well thought out and encompasses the entire scope of scientific evidence.

Such robust regulation must then be demonstrably adhered to by industry through auditable quality systems, test methods and results. Participation in accreditation and certification schemes can also play its part in helping to demonstrate to consumers that independent oversight of industry exists, thus promoting consumer confidence in food that fraud can often destroy.

## How we need to adapt food regulation to endure major global events

One consequence of the global COVID-19 pandemic has been a shift in supply chains. Countries have become more protective of the food they produce, and consumers are more aware of locally available foods and in some cases demand it, feeling that somehow it is safer. Many local food stores benefitted from the fact that supermarkets occasionally struggled to meet demand, with their complex and extended supply chains; while catering suppliers have found safe and creative ways to repurpose supplies that would usually go to hospitality outlets.

The pandemic and its aftermath have placed the food industry at a fork in the road, where the route chosen will shape the future of food for years to come. We have choices as to how the food industry should be structured to meet the challenges of the future, whether it's another pandemic, the consequences of climate change, or simply meeting the needs of a globally expanding population.

These choices include the opportunity for industry to work together with scientists and regulators to rebuild robust sustainable supply chains, supported by reliable, validated and reproducible detection methods, whether these be qualitative or quantitative. As the panel discussed, a global, collaborative mindset is what will help pull millions of people back from the brink of starvation. We encourage those in our industry with food safety knowledge and insights to share this invaluable information and collaborate with inter-governmental and non-governmental organisations. With help, safety will out.

## Reference

1. www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=1568667

# How to cope in a fast-moving environment

**In today's uncertain and fast-moving world, food and beverage companies have to innovate more quickly than ever to simply exist. Siemens offers insight to help companies manage.**

DIGITALISATION, regulations, new consumer behaviours, complex supply chains, fierce competition – it's a fast-moving world out there. In order to stay competitive in this global market and keep consumers loyal to their brands, manufacturers need to innovate continuously, developing new products, applications and entering novel markets.

Consumers are becoming more health- and environmentally conscious, and as such, require products to be healthy, safe and sustainable. They also expect a greater choice of products delivered in larger arrays of pack types and sizes.

Moreover, we are witnessing a simultaneous call for premium quality products and low prices for standard lines. Customers are demanding greater transparency in order to assure them about the quality and authenticity of the product, as well as to be able to select a more sustainable supplier over another one.

On top of that, the industry is becoming increasingly regulated, which has also served to impact product development and the supply chain.

These challenges confront the industry with the following requirements:

1. **Reducing time-to-market** – Due to faster changing consumer demands, producers must launch products faster
2. **Enhancing flexibility** – Consumers want individualised products but at the prices they would pay for mass-produced goods. Consequently, production must be more flexible
3. **Delivering premium quality** – Consumers reward high quality by recommending products on the Internet – and they punish poor quality the same way
4. **Becoming sustainable** – Today, it is not only the product that needs to be sustainable and environmentally friendly, energy efficiency in production becomes a competitive advantage too
5. **Selling trust** – This can only be realised by being transparent. Technology such as QR codes on packaging, which can provide product verification and details of its journey, are becoming the new standard.

To meet these requirements, Siemens launched its formulated product design solution comprising six components that work closely together on one integrated platform. This enables the creation of a 'digital thread' from idea generation to startup in production.

## Formulated product design solution

The user can outline their brief and targets in the electronic notebook, which can be tracked throughout the process.

The formula workbench then allows one to set up a digital twin of their formulation; they continue only with these digital alternatives, allowing them to experiment with what works best. As early on as initial formula development, the regulatory compliance of the formulated products can be assured.

The final formulation can be saved directly in the specification management system on the same platform – a single repository for all material specifications company-wide.

The supplier collaboration feature allows the user to involve a supplier in the development process to save time and cost.

Finally, by integrating Siemens laboratory information management system (LIMS), the quality loop can be closed during the development process and throughout production via at-line or off-line testing.

The formulated product design solution ultimately empowers manufacturers to design, develop and test formulated products in a flexible, efficient and comprehensive way, while reducing time-to-market and lowering costs and complexity. Moreover, the user can maintain data consistency, remain compliant with regulations and assure product quality from inbound to outbound.

## Conclusion

Siemens Manufacturing Operations Management (MOM) software offers a holistic solution that enables you to implement your strategy for the complete digitalisation of manufacturing operations.

The portfolio provides end-to-end visibility of production, allowing decision makers to readily identify areas to be improved within both the product design and associated manufacturing processes, and make the necessary operational adjustments for smoother and more efficient production.

Our portfolio provides solutions for:

- Advanced planning and scheduling
- Manufacturing execution
- Quality management
- Manufacturing intelligence
- Formulated product design.

**Filip Schiettecat**
Senior Director Industry Management, Siemens Digital Industries Software

## Example from a dairy company

**Challenges:**
- Growing productions and strict quality standards
- Urgent need to upgrade traditional manual quality control to a digitalised system
- Regulatory compliance.

**Results:**
- One central LIMS for all laboratories
- 34 quality control labs and two R&D labs equipped
- Over 90 percent of test data collected and uploaded automatically
- 1,400 test methods standardised
- Test time saving of 10-25 percent.

SIEMENS

Scan me

# Applications of hyperspectral imaging in food safety

**Investigating hyperspectral imaging as a rapid analysis alternative to traditional food safety techniques.**

UNSAFE FOODS containing harmful bacteria, viruses, parasites or chemical substances, can cause more than 200 diseases. According to the World Health Organization,[1] unsafe food causes 600 million foodborne illness cases with 420,000 deaths every year. The rapid and accurate detection of microbiological and chemical hazards plays a crucial role in protecting consumers from contaminated foods and ensuring food safety. However, traditional methods that assess microbiological and chemical hazards are tedious and time consuming. For example, current pathogen detection approaches, ranging from culture-based methods to molecular technologies, can take days or up to a month to obtain the results. These delays adversely impact operating cycles, and some food businesses may risk a possible food recall to allow their products to move onto the next step in the food supply chain before receiving the results.

To improve the efficiency of food testing, some researchers focus on modifying the traditional approaches to accelerate their determination procedures, while others attempt to find an alternative technique to replace the traditional methods. Hyperspectral imaging (HSI) technique combining spectroscopy with computer vision has the capability to identify food components and visualise their distributions. Therefore, hyperspectral imaging technique has emerged as a non-invasive, rapid, chemical-free and environmentally-friendly method, and represents an alternative tool for food safety assessment.

## A closer look at the hyperspectral imaging technique

HSI integrates spectroscopic and imaging techniques into a single system and is capable of collecting hundreds of images at different wavelengths. Just as humans can see seven colours in a rainbow, the HSI system can detect hundreds of colours in each small point of an image. This feature allows HSI to visualise the chemical images of foods. To illustrate the procedures involved in using the technology to assess food safety, an example using HSI to predict the total viable counts (TVC) of bacteria in grass carp fillets[2] is presented here:

1. Detecting reference values of TVC in fish fillets using traditional standard plate count method according to UNE-EN ISO 4833:2003
2. Taking hyperspectral images of fish fillets by a HSI system
3. Using machine learning methods to establish a model between the reference values of TVC and their corresponding hyperspectral images
4. Applying the established model to predict the TVC values of grass carp fillets based on their hyperspectral images
5. Generating the TVC distribution maps of fish fillets.

If the value of TVC in a fish fillet exceeds $10^7$ colony-forming units (CFU) per gram or $cm^2$, it is considered dangerous for consumption and can cause illness. **Figure 1** gives examples of using HSI to visualise the microbial distribution of fish fillets at different storage stages. Fish fillets with higher TVC values appear in red, while those with lower TVC values are in blue. Therefore, we can know if a fish fillet is safe to progress to

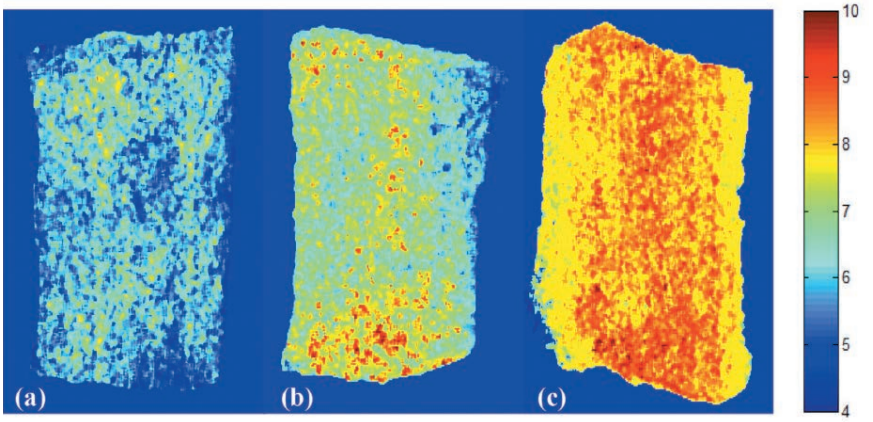
the next step in the food supply chain through the HSI prediction results and visualisation maps.

Over the past decade, our research group has focused on employing HSI for food quality and safety analyses. The applications of HSI in microbial safety detection, freshness assessment and adulteration identification are discussed below to demonstrate how HSI works to ensure food safety.

## Microbial safety detection

Enterobacteriaceae is a large family of bacteria associated with the intestines and faeces of animals. *Escherichia coli* (*E. coli*) and *Salmonella*, which are among the most common pathogens affecting millions of people annually, are included in this family. Enterobacteriaceae is usually used as a hygiene indicator organism. If the level of Enterobacteriaceae in ready-to-eat foods is under 100 CFU/g, it means that the foods are safe for consumption. In 2013, we used hyperspectral imaging alongside chemometric models to detect Enterobacteriaceae on chicken fillets.[3] The prediction error for the model is 2.82 CFU/g, which means that HSI is feasible for the accurate detection of Enterobacteriaceae. *E. coli* is another hygiene indicator organism in ready-to-eat foods. If *E. coli* counts in ready-to-eat foods are under 20 CFU/g, it is regarded as satisfactory. We adopted HSI to measure *E. coli* loads (104-1010 CFU/g) in grass carp fish and acquired a prediction error of 1.83 CFU/g.[4] These results are helpful for promoting the applications of HSI in monitoring and evaluating bacterial contamination in the food industry.

**Figure 1**

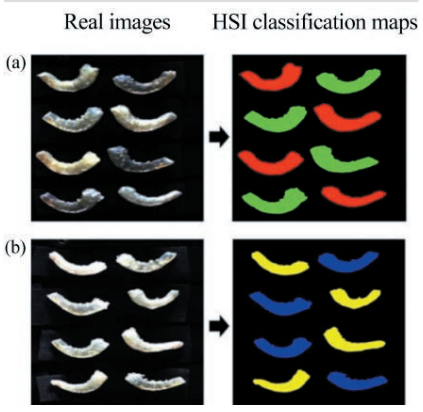



Distribution maps of microbial spoilage in fish fillets at three storage stages: (a) Day one; (b) Day five; (c) Day ten

## Freshness assessment

K-value is used to indicate and evaluate the freshness of fish. The change of the K-value in the postmortem relates to the degree of spoilage. A K-value »

**Figure 2**




Visualisation maps for prawn adulteration: (a) unfrozen groups, and (b) frozen groups

below 20 percent indicates optimal fish freshness. A K-value ranging from 20-40 percent is the secondary freshness, while 60-80 percent indicates the incipient spoilage of fish. When a K-value of fish is higher than 40 percent, it means that the fish has reached its shelf-life terminal point. Traditionally, the K-value is detected by using high-performance liquid chromatography (HPLC), which requires extraction of the fish and chemicals to do the detection, resulting in a tedious, time-consuming and environmentally unfriendly detection procedure. HSI, which is emerging as a rapid, non-invasive, and chemical-free detection method, is more environmentally friendly than the traditional method. In 2015, we started to use HSI to evaluate the K-value of grass carp and silver carp fillets and obtained a prediction error of 5.17 percent,[5] which implied the feasibility of using HSI for the evaluation of chemical spoilage and freshness loss in fish fillets.

Another important freshness index is 2-thiobarbituric acid reactive substances (TBARS) that indicates the degree of lipid oxidation, which is a leading cause of freshness loss. Products must not be placed on the market if chemical tests reveal the products are above the limits of TBARS. We employed HSI to predict TBARS contents in chicken meat during storage[6] and demonstrated that HSI is a promising tool for the rapid determination of TBARS for freshness evaluation of chicken meat.

## Adulteration identification

Economically motivated adulteration causes a threat to food safety and public health. Due to the easy death and high perishability of prawns, unprocessed prawns mainly appear in the form of fresh tails and frozen tails. Some dishonest traders adulterate unfrozen and frozen prawn products with soaked or even deteriorated prawns. The soaked prawn is more vulnerable and easier to rot than its fresh counterpart; however, it is difficult to differentiate soaked prawns from fresh prawns solely by eye. Therefore, we utilised HSI to distinguish the soaked prawns from fresh ones in unfrozen and frozen samples[7] and achieved an accurate classification rate of 98.33 percent and 95 percent in unfrozen and frozen prawns, respectively.

**Figure 2** presents the real and HSI visualisation images of prawns. As you can see, it is difficult to recognise the soaked and fresh prawns by the photographic images; however, it is straightforward to identify these two different prawns via HSI classification maps. To clarify, for the unfrozen group, the fresh and soaked samples are respectively coloured in green and red. For the frozen group, the fresh samples display in blue, while the soaked prawns appear in yellow.

## Conclusions and future trends

This article introduces our work regarding applications of HSI in the detection of microorganisms, freshness and adulteration of foods. We also employ spectroscopic and hyperspectral imaging techniques to evaluate other food quality attributes, such as appearance, texture, ripeness and chemical components, and detect foreign objects, pesticide residues and mechanical damages.

Most of the research regarding applications of HSI in food quality and safety analyses are conducted at the laboratory scale, which proves the potential application of HSI in the food industry. Some companies, such as IRIS Technology Group, have developed an industrial in-line hyperspectral imaging analyser for real-time and continuous chemical components-monitoring of food products.

Furthermore, the combination of HSI with smartphones enables customers to test ingredients or food products when shopping at markets or checking stored foods at home. However, the research of integrating HSI with a smartphone is still in the very early stages, and we are as yet far away from making this technically possible. However, the implementation of such devices will benefit people worldwide and greatly improve our quality of life.


**Professor Da-Wen Sun**

Professor Da-Wen Sun is a global authority in food engineering research and education. He is an Academician of six academies, including Member of the Royal Irish Academy, Member of the Academia Europaea, Foreign Member of the Polish Academy of Sciences, Fellow of the International Academy of Food Science and Technology; Fellow of the International Academy of Agricultural and Biosystems Engineering, and Full Member of the International Academy of Refrigeration.

**Xiaohui Lin**

Xiaohui Lin is a PhD student under the supervision of Professor Da-Wen Sun at UCD, Ireland. Her research interests include state-of-the-art applications of spectrospcopy and hyperspectral imaging in the field of agricultural and food science. She is the (co-)author of 10 publications in scientific journals.


## References


1. Food safety. https://www.who.int/news-room/fact-sheets/detail/food-safety.
2. Cheng J-H, Sun D-W. Rapid and non-invasive detection of fish microbial spoilage by visible and near infrared hyperspectral imaging and multivariate analysis. Food science & technology. 2015;62(2):1060-8.
3. Feng Y-Z, ElMasry G, Sun D-W, Scannell AG, Walsh D, Morcy N. Near-infrared hyperspectral imaging and partial least squares regression for rapid and reagentless determination of Enterobacteriaceae on chicken fillets. Food Chemistry. 2013;138(2-3): 1829-36.
4. Cheng J-H, Sun D-W. Rapid quantification analysis and visualization of Escherichia coli loads in grass carp fish flesh by hyperspectral imaging method. Food and Bioprocess Technology. 2015;8(5):951-9.
5. Cheng J-H, Sun D-W, Pu H, Zhu Z. Development of hyperspectral imaging coupled with chemometric analysis to monitor K value for evaluation of chemical spoilage in fish fillets. Food Chemistry. 2015;185:245-53.
6. Xiong Z, Sun D-W, Pu H, Xie A, Han Z, Luo M. Non-destructive prediction of thiobarbituricacid reactive substances (TBARS) value for freshness evaluation of chicken meat using hyperspectral imaging. Food Chemistry. 2015;179:175-81.
7. Dai Q, Cheng J-H, Sun D-W, Pu H, Zeng X-A, Xiong Z. Potential of visible/near-infrared hyperspectral imaging for rapid detection of freshness in unfrozen and frozen prawns. Journal of Food Engineering. 2015;149:97-104.

# RESTEK | ADVANTAGE

See What It Can Do for You and Your Lab

- Technical Articles & Applications
- Videos & ChromaBLOGraphy
- FAQs & Troubleshooting
- Education & Instruction
- Online Tools & Calculators
- Product Selection Assistance

Sign up today to access Restek's years of chromatography knowledge at

**www.restek.com/advantage**


RESTEK Pure Chromatography

# Olive oil frequently asked questions

**In this two-part article, researchers from the OLEUM Project tackle some frequently asked technical questions posed by the public and researchers around olive oil, including quality, shelf life and sustainability.**

CO-ORDINATED by Professor Tullia Gallina Toschi from the Alma Mater Studiorum, University of Bologna, OLEUM is an EU H2020-funded project which aims to guarantee olive oil quality and authenticity by empowering detection and fostering prevention of olive oil fraud. Here, in the first of a two-part article, several of its researchers answer some frequently asked questions, demystifying some common queries and misconceptions on oils.

## Q: Does the colour of olive oil give an indication of its quality?

**A:** The colour, which can be anywhere from light golden yellow, to intense dark green, does not give an indication of the olive oil quality. The colour is a result of a number of substances (chlorophylls, carotenoids, phenols, pyropheophytines, etc) solubilised in differing amounts in the oil, which depends on an array of variables (eg, olive

cultivar, harvest time, ripening index, pedoclimatic conditions, type of extraction and extraction plant, and eventual refining).

Therefore, an olive oil (yellow or green) can be extra virgin or virgin (top qualities), or refined (eg, olive oil and olive pomace oil), or even lampante (refined, but not edible). However, it is important to note that an extra virgin olive oil produced and conserved in the same conditions (same olives cultivars, geographical area, seasonality, extraction plant, storage condition of olives and oil) is expected to have a reproducible colour year-on-year. For this reason, the colour, if correctly defined and evaluated, could be an index of specificity for typical productions and could be included as a quality attribute in the Single Document of a PDO (protected designation of origin).

**Q: Does the process of winterisation of olive oil affect the compounds known for health benefits (phenolic compounds, etc) and the quality or shelf life of the oil?**

**A:** Some olive oil producers winterise their olive oil so that during the winter months it does not become solidified on cellar shelves. The winterisation step is typically applied in refined seed oils to reduce waxes and long-chain saturated triglycerides. However, it is not commonly applied in virgin olive oil. Winterisation involves cooling the oil (5-8°C) to allow crystallisation in 24 to 48 hours. The separation of the two phases is done via filtration or centrifugation. If the winterisation was applied to virgin olive oil, which is not usually the case, a minor change would be expected in the content of phenols (and in their corresponding contribution to shelf life) derived from water removal in the filtration process.

**Q: It has been proven that olives grown in hotter climates have higher wax contents than those from colder climates; what effect/benefits does the wax content have on the oil?**

**A:** Waxes are present on the fruit skin (epicarp) with the function to protect the inside of the fruit from the rain and limit the excessive evaporation/transpiration of water. Wax extraction and its absorption into the oil is more efficient when solvents are used; however, a limited amount of wax can be extracted by the oil itself when using mechanical methods of extraction.

In hot climates, olive fruits can arrive at the mill at rather high temperatures, which makes the wax more prone to be extracted by the oil. Mechanical extraction of oil from olives, when high temperatures or drastic conditions are applied, can also promote the extraction of wax, but a higher or lower content of wax has no benefit on the oil quality.

**Q: Why do tyrosol derivatives have to be quantified in the calculation of olive oil polyphenols content to support the health claim provisioned in the EC Reg. 432/2012?**

**A:** Tyrosol, in free and complex forms, is absorbed by humans upon olive oil consumption. The complex tyrosol forms are partially hydrolysed in the gastrointestinal tract and the colon, giving rise to free tyrosol. Tyrosol can be converted *in vivo* to hydroxytyrosol.

Tyrosol and its metabolites bind to low-density lipoproteins (LDL), suggesting a possible protective effect on their oxidation. Despite the lack of *in vivo* data, cell-mediated oxidation experiments of LDL[1] showed that tyrosol provided a 40 percent »

*"In hot climates, olive fruits can arrive at the mill at rather high temperatures, which makes the wax more prone to be extracted by the oil"*

inhibition, whereas it could protect Caucasian colon adenocarcinoma (Caco)-2 cells from injury induced by oxidised LDL.[2] Therefore, tyrosol inclusion in a health claim is scientifically supported and meaningful.

### Q: Is it true that the more bitter the virgin olive oil, the better the quality?

**A:** Bitterness and pungency have been related to specific phenolic compounds in virgin olive oils. Although several studies in literature pointed out that these minor compounds play an important role in human health, protecting the blood lipids from oxidation (EC Reg. 432/2012), it is well known that the rejection of bitterness and pungency is a natural reaction for consumers. Phenolic compounds also help maintain the overall quality of virgin olive oils during their storage. This highlights the need for further efforts to disseminate to consumers the positive meaning of bitterness and pungency perceived in virgin olive oil.

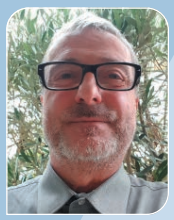
### Q: Why is olive oil sometimes cloudy – is it a defect or does it mean it's more ecological/organic?

**A:** There are two reasons for the cloudiness of olive oil. One could be that part of the major components of the oil (triglycerides) moved to a solid state due to cold temperatures during the storage of the oil pallet before bottles were taken and put on the supermarket shelf. This phenomenon is reversible within a rather short time after exposure at room temperature.

Equally, if the olive oil is not filtered, some cloudiness can be expected due to the presence of tiny particles of organic material (olive flesh), as well as emulsified water in the bottle.

Neither of these circumstances which lead to cloudiness indicate low (or high) product quality.

EXPERT VIEW



**Dr Hansjörg Majer**
European Business Development Manager, Restek

RESTEK

For further information, visit:
**www.restek.com**

# New opportunities in polar contaminant analysis

**Dr Hansjörg Majer explains how new LC column phase technology is advancing the analysis of polar contaminants in food.**

Historically, polar contaminants have been difficult to reliably quantify using common analytical techniques like GC or reversed-phase LC. However, advances in LC column phase chemistry are creating new opportunities for the analysis of these polar contaminants in water and foodstuffs.

Polar contaminants of particular interest are polar pesticides, nitrosamine precursors, and a newly emerging group of persistent, mobile and toxic (PMT) contaminants, with poly- and perfluoroalkyl substances (PFAS) being a prime example.

In the drinking water sector, with the advent of suitable analytical methods, calls for guideline and limit values of PMTs have been growing louder since 2018. Experience shows that this will also be applied to other foodstuffs as these mobile contaminants can be present in plant- or animal-based commodities.

In addition to ion chromatography (IC)/MS and supercritical fluid (SFC)-MS, novel HILIC or mixed-mode separation phases for LC-MS/MS have proven to be valuable tools for developing suitable methods. Various suppliers have now successfully applied novel mixed-mode separation phases to the analysis of polar pesticides and polar, short-chain PFAS.

Restek introduced a novel, hybrid ligand column – Raptor Polar X – last year, offering a better way to achieve both retention and separation of small polar contaminants. It has already been successfully applied to mini-screening methods targeting larger groups of similar compounds.

Using a Raptor Polar X column, up to 17 polar pesticides can be detected in a single, fast analysis; the development of a new method based on this column was recently included in the QuPPe document of the European Reference Laboratory for Single Residue Analysis.

We expect the landscape of separation solutions for small polar contaminant testing will continue to evolve with the emergence of novel and innovative new technologies in the near future, providing LC-MS/MS platform users with suitable tools to improve the quantitative and qualitative determination of polar contaminants in our food supply.

The colour of olive oil, which can be anywhere from light yellow to dark green, does not give an indication of the olive oil's quality

## Q: Is there an interest in vegetable oils obtained by co-milling olives with other products?

**A:** Vegetable oils obtained by co-milling olives with other products are interesting from a technological, nutritional and sensory point of view. These oils obtained solely by mechanical extraction can show interesting sensory profiles, due to the presence of olfactory, tactile or tasting active compounds derived from fruits, spices and by-products (lemon, capsicum, tomato peels and seeds). The nutritional and health properties are linked with their content in active lipophilic compounds (eg, lycopene from tomato peels and seeds). The mechanical extraction uses olive oil as the sole solvent and any other chemicals are not required, thus achieving a fully sustainable green process.

There is particular interest in developing natural and sustainable products, which also offer an array of choice in terms of flavouring, and the haute cuisine arena has shown enthusiasm for these new oils, with a view to fostering and enlarging the knowledge and consumer demand around virgin olive oils.

## Q: How can we make olive oil production more environmentally friendly?

A: There are several technologies to recover phenolic compounds from the olive vegetation waters – a by-product of olive oil production. The olive vegetation water treatments are typically based on membrane filtration (ultrafiltration, nanofiltration and reversed osmosis) and/or the phenolic absorption using active resins that reduce the environmental impact of the vegetation waters, while at the same time, producing a phenolic extract.

The phenolic extract, characterised by various levels of purity, can be used in food processing as an ingredient with antioxidant and antimicrobial properties, or to produce functional food enriched with bioactive phenols.

For more information about olive oil, visit: **www.oleumproject.eu**


### Contributions

This article was authored by a range of experts, including Professor Tullia Gallina Toschi (Alma Mater Studiorum – Università di Bologna, IT), Dr Diego Luis García González (CSIC – Instituto de La Grasa, SP), Professor Alessandra Bendini (Alma Mater Studiorum – Università di Bologna), Professor Maria Tsimidou (Aristotle University of Thessaloniki, GR), Dr Florence Lacoste (ITERG, FR), Professor Maurizio Servili (University of Perugia, IT), Dr Wenceslao Moreda (CSIC – Instituto de La Grasa, SP), Professor Lanfranco Conte (President of the Italian Society for Fats and Oils Researches), and Professor Paul Brereton (Queen's University Belfast, UK) who was responsible the overall concept of OLEUM's Question of the Month and the OLEUM Network. Dr Tassos Koidis (Queen's University Belfast, UK) curated the questions and answer list in this article and coordinates the OLEUM Network where these questions were originally posted.



### Disclaimer

This article was developed in the context of the project OLEUM 'Advanced solutions for assuring authenticity and quality of olive oil at global scale', funded by the European Commission (EC) within the Horizon 2020 Programme (2014–2020, GA no. 635690). The information expressed in this article reflects the authors' views; the EC is not liable for the information contained herein.


*"There is particular interest in developing natural and sustainable products"*

### References


1. Di Benedetto, *et al.* 2007, *Nutr. Metabol. Cardiovasc. Dis.*, 17, 535
2. Giovannini, *et al.* 1999, *J. Nutr.*, 129, 1269