ACRYRED

Acrylamide in Cereal Products: Progress and Prospects

June 3rd- 4th 2026

Splendid Hotel La Torre, Palermo, Italy

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EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

PROGRAMME and ABSTRACTS

Meeting organised by ***Association of Applied Biologists***
Warwick Enterprise Park, Wellesbourne, Warwick CV35 9EF, UK
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Acrylamide in Cereal Products: Progress and Prospects

Acrylamide is a toxic processing contaminant that forms during both industrial food processing and home cooking. It is classed as a probable human carcinogen and can affect the nervous system and fertility at high doses. Baked cereal products are a major source of exposure for consumers, along with fried and roasted potatoes, including crisps (chips) and French fries, and coffee. The current EU Regulation on acrylamide (Regulation (EU) 2017/2158) requires all food businesses to monitor the levels of acrylamide in their products, sets out compulsory mitigation measures and establishes Benchmark Levels for a range of food types. This year, the European Commission is expected go further with the setting of Maximum Levels, above which it would be illegal to sell a product, increasing the pressure on food businesses and potentially threatening the availability of some foods.

Acrylamide forms from free (soluble, non-protein) asparagine and reducing sugars (principally glucose, fructose and maltose) during frying, baking, roasting and toasting. For years, the whole cereal supply chain has been engaged in reducing acrylamide formation in cereal products, developing genetic and agricultural solutions, optimising processes, implementing quality control measures and establishing guidelines. The progress that has been made and the prospects for further improvement will be covered in this conference.

Programme

Wednesday June 3rd

1800 **Evening Social Reception**
Registration and apertif
Bar area, Splendid Hotel La Torre

Thursday June 4th

0800-0900 Registration open
Congress center, Tancredi Room, Splendid Hotel La Torre

0900- 0910 Official opening and ACRYRED progress report
Nigel Halford (ACRYRED Chair)

0910- 0940 Nutritional improvement of wheat using TILLING, transgenesis and genome editing
Stefania Masci (DAFNE Università della Tuscia, Italy)

0940-1050 **SESSION 1: Acrylamide mitigation and the cereal supply chain**

Session Chairs: Zuzana Ciesarova (National Agricultural and Food Centre, Bratislava, Slovakia)
Burce Atac Mogol (Food Engineering, Hacettepe University, Ankara, Turkey)

0940-0950 Introducing systematic review on acrylamide: addressing health risks and mitigation measures
Zuzana Ciesarova (National Agricultural and Food Centre, Bratislava, Slovakia)

0950-1020 Regulation and Competition: The Impact of Acrylamide Limits on the Grain Market
Veronica Nowakowski (University of California, Berkeley, USA)

1020-1035 Acrylamide Risk Awareness Across The Cereal Supply Chain: From Breeding To Consumption
Anna Szafrańska (Dąbrowski Institute of Agricultural and Food Biotechnology, Warsaw, Poland)

1035- 1050 Occurrence And Reduction Of Acrylamide In Cereal-Based Products In Spain: Evidence From Long-Term Monitoring
Marta Mesias (Institute of Food Science, Technology and Nutrition (ICTAN-CSIC), Madrid, Spain)

1050-1120 **BREAK**

1120-1250 **SESSION 2: Updates on Chemistry & Processing to reduce acrylamide**

Session Chairs: Jane Parker (University of Reading, UK)
Beka Saric Nešković (Maize Research Institute Zemun Polje, Belgrade, Serbia)

1120-1150 Acrylamide: Formation, Mechanism and Reactions
Vural Gökmen (Hacettepe University, Ankara, Turkey)

1150-1220 A cereal manufacturer's view on acrylamide: challenges and pathways forward within the framework of BMLs and MLsd
Colm Campion (Cereal Partners Worldwide- Nestle, UK)

1220-1235 Acrylamide Mitigation In Red Lentil Cookies Using Filamentous Fungi Fermentation Within A Targeting Asparagine Reduction Approach
Kristína Kukurová (National Agricultural and Food Center, Bratislava, Slovakia)

1235-1250 Impact Of Air-Fryer Technology On The Formation Of Heat-Induced Contaminants In Cereal-Based Biscuits
Kubra Damla Ekenci (Bandırma Onyedi Eylül University, Balıkesir, Türkiye)

12:50-13:50: **LUNCH**

1350-1400 Conference Photo

1400-1530 **SESSION 3: Updates on molecular and breeding instruments for lowering free asparagine**

Session Chairs: Elena Baldoni (IBBA, National Research Council, Milan, Italy)
Anna Szafranska (Waclaw Dabrowski Institute of Agricultural and Food Biotechnology, Warsaw, Poland

1400-1430 Four years of ACRYRED Working Group 2 “Agronomy and Plant Breeding”: progress on knowledge about free asparagine accumulation in cereals
Elena Baldoni (IBBA, National Research Council, Milan, Italy)

1430-1500 Reducing the acrylamide-forming potential of wheat, from fertilisation rates and disease control to CRISPR
Nigel Halford (Rothamsted Research, UK)

1500-1515 Optimising Free-Asparagine Determination And Oven Humidity To Mitigate Acrylamide Formation
Hind El Hadri (European Commission, Joint Research Centre (JRC), Italy)

1515-1530 Genotype, Environment And Management Effects On Free Asparagine Content In Winter Rye Grain
Matěj Satranský (Czech University of Life Sciences Prague, Czech Republic)

1530-1600 **BREAK**

1600-1700 **SESSION 4: Acrylamide and human health**

Session Chair: Malgorzata Starowicz (Polish Academy of Sciences,Olsztyn, Poland)

1600-1630 Acrylamide and Health risks: Evidence and Uncertainty
Federica Gilardi (Faculty Unit of Toxicology, University Center of Legal Medicine, University of Lausanne)

1630-1700 Concentration Targets: An ACRYRED View
Neil Buck (General Mills, Switzerland)

1700-1810 **Round-table Discussion**: **Integration of Knowledge on Asparagine and Acrylamide for health and legislation. What to do now?**

Panel Participants:

Viktor Korzun
Federica Gilardi
Colm Campion
Marta Mesias
Nigel Halford

1810-1815 **Final comments and next steps**

1900: Conference Dinner (optional)
Location: TBC with 15-minute walk of the conference hotel

Poster Presentations

P1	**Hyrije Koraqi**	Analysis Of The Formation, Identification And Mitigation Of Acrylamide In Cereal-Besed Food Products
P2	**Angel Angelov**	Effects Of Sourdough On Acrylamide Content Gluten-Free Sorghum Bread
P3	**Özge Süfer**	Interaction Of Dietary Acrylamide With Gut Microbiota
P4	**Mitar Delević**	Acrylamide Intake From Food In Montenegro: Exposure Assessment And Population Risk
P5	**Menekşe Bulut**	“Acrylamide Reduction In Cereals: Aroma Trade-Off”
P6	**Maria Różańska**	Effect Of Rice Flour Extrusion On Precursors And Their Contribution To Acrylamide And 5-Hydroxymethylfurfural Formation
P7	**Veton Haziri**	Chemistry-Guided Understanding Of Acrylamide Formation And Detection In Cereal Products: From Reaction Pathways To Analytical Innovation
P8	**Rozarta Nezaj**	Nutritional Impact And Health Effects Of Gluten-Containing Cereals
P9	**MICHELA QUIQUERO**	Selection And Recombination Of Targeted Milling Fraction For Acrylamide Mitigation In Neapolitan Pizza
P10	**Muhammad Nouman Shaukat**	Targeted Delivery Of Encapsulated Polyphenol-Rich Artichoke Extract For Acrylamide Mitigation In Cereal Based Food Systems
P11	**Fitim Kastrati**	Integrating Phenotyping And Regulatory Approaches To Understand Acrylamide Risk In Cereal Crops
P12	**Dino Hasanagic**	Monitoring Acrylamide Concentrations In Domestic And Imported Potato Chips Sold In Montenegro
P13	**Marina Roldán**	Evaluation Of Acrylamide Content In Wholegrain Crackers: Balancing Nutritional Value And Chemical Safety
P14	**Meleksen Akin**	Global Research Trends In Acrylamide Formation In Wheat-Based Products: A Bibliometric Perspective
P15	**Zuzana Ciesarova**	Instrumental Colour Parameters As A Screening Tool For Acrylamide In Extruded Snacks
P16	**Osman Fetoshi**	Side Effects Of Acrylamide On Health
P17	**Pajtim Bytyci**	Exploring The Knowledge, Attitudes And Practices Of Young People In Kosovo Towards Acrylamide In Food
P18	**Beka Nešković**	Effect Of Species, Cultivar And Year On Free Asparagine Accumulation In Cereal Grains And Consequently On Acrylamide Formation In Cookies
P19	**Nigel Halford**	Reducing The Free Asparagine Content Of Wheat Grain Through Crop Management, Imaging And Genetics
P20	**Jane Parker**	A Food Systems Approach To Mitigating Acrylamide

ASSOCIATION OF APPLIED BIOLOGISTS

ENQUIRIES

Enquiries concerning the technical content of the Abstracts should be addressed directly to the authors; however, other matters should be directed to the Executive Officer, Dr Geraint Parry (geraint@aab.org.uk) at the AAB Office, Warwick Enterprise Park, Wellesbourne, Warwick CV35 9EF, UK

Session 1: Acrylamide mitigation and the cereal supply chain

Nutritional improvement of wheat using TILLING, transgenesis and genome editing

STEFANIA MASCI

[1]*DAFNE, University of Tuscia, Via San Camillo de Lellis, snc, Viterbo, Italy*

ABSTRACT

Consumers are increasingly attentive to the quality of wheat-based products, and wheat remains a staple food for the majority of the world's population. This presentation focuses on several targets aimed at improving the nutritional properties and safety of wheat.

1. **Reduction of components potentially involved in Non-Celiac Wheat Sensitivity (NCWS):** Alpha-amylase/trypsin inhibitors (ATIs) are considered among the most likely triggers of NCWS. Both durum and bread wheat have been engineered using RNA interference (RNAi) and CRISPR-Cas9 genome editing to silence specific ATI genes.
2. **Enhancement of nutritional traits (resistant starch and biofortification):** Durum wheat lines have been developed by crossing mutant lines derived from TILLING platforms. To increase resistant starch, *SBEIIa* genes have been silenced, resulting in higher amylose content. For provitamin A biofortification, *LCYE* and *HYDB* genes have been targeted to promote β-carotene accumulation. In addition, genes involved in phytic acid biosynthesis have been silenced to enhance iron bioavailability.
3. **Reduction of acrylamide formation in baked products:**Using a TILLING population of the bread wheat cultivar Cadenza, null alleles of *Asn-2* genes have been pyramided and backcrossed to elite varieties to generate wheat lines with reduced potential for acrylamide formation, suitable for different end uses.

Overall, these results demonstrate how the integration of classical breeding approaches with advanced biotechnological tools can generate wheat lines with improved nutritional value and provide insights into the role of specific components in wheat-related disorders.

Regulation and Competition: The Impact of Acrylamide Limits on the Grain Market

VERONICA NOWAKOWSKI[1]

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ABSTRACT

This presentation examines how emerging acrylamide regulations may affect competition in the European grain market. Acrylamide is a food safety concern formed during high-temperature processing, and its formation is linked to free asparagine levels in wheat. Although the wheat market is often described as near-competitive because of standardized products, transparent pricing, and many dispersed producers, new regulatory requirements may change how firms compete. The presentation focuses on how stricter acrylamide standards could create uneven compliance burdens across the supply chain. Larger millers and food manufacturers may be better able to invest in testing, monitoring, and specialized sourcing systems, while small and mid-sized firms may face higher costs and reduced access to compliant wheat. These pressures could raise barriers to entry, strengthen contract-based supply arrangements, and contribute to greater market concentration. By connecting food safety regulation with market structure, the presentation highlights a key policy tension: regulations that improve consumer protection may also unintentionally privilege firms with greater capital and infrastructure. The presentation concludes by considering policy options that can support effective acrylamide reduction while preserving fair competition and equitable market access for smaller firms.

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ACRYLAMIDE RISK AWARENESS ACROSS THE CEREAL SUPPLY CHAIN: FROM BREEDING TO CONSUMPTION

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ABSTRACT

Poland is a leading cereal producer in the European Union, with total harvests reaching 37.3 million tonnes in 2025, which are used to produce approximately 1.4 million tonnes of fresh bread and 0.4 million tonnes of cakes and confectionery products annually. Despite the scale of production, acrylamide remains primarily a topic of scientific research and bakery-sector practice rather than a widely recognized issue across the supply chain.

In early 2026, a survey was conducted to assess awareness of acrylamide risks among key stakeholders: plant breeders (n=28), farmers (n=240), milling companies (n=23), bakeries (n=45), and consumers (n=600). The results reveal significant gaps in knowledge and communication.

Among breeders, 86% were unfamiliar with EU Regulation 2017/2158, 82% did not assess risk of free asparagine levels in breeding materials. Limited engagement is partly due to a lack of demand signals from downstream sectors. Farmers showed similarly low awareness: 62% had never encountered the concept of acrylamide in cereal products, and most lacked knowledge of agricultural practices influencing asparagine levels, including sulfur fertilization.

Milling companies demonstrated limited involvement, with 83% not measuring free asparagine in grain and obtained flours and few implementing mitigation strategies. Only 17% reported using asparaginase in the range of 0.004 to 0.08%. Information exchange between supply chain actors was minimal.

In contrast, bakeries exhibited high awareness: over 80% conduct regular risk assessments, implement mitigation measures, and monitor acrylamide levels in accordance with EU requirements.

Consumer awareness was also limited: only 56% recognized products potentially containing acrylamide, while 80% based bread choice primarily on crust color.

The findings highlight the urgent need for improved education and communication across the entire cereal supply chain to effectively reduce acrylamide formation from farm to fork.

OCCURRENCE AND REDUCTION OF ACRYLAMIDE IN CEREAL-BASED PRODUCTS IN SPAIN: EVIDENCE FROM LONG-TERM MONITORING

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ABSTRACT

Acrylamide is a process contaminant formed during the thermal treatment of carbohydrate-rich foods, particularly cereal-based products, and its presence has raised significant food safety concerns. In response, the European Union has established benchmark levels and mitigation strategies based on product reformulation and optimization of processing conditions (EC, 2017). In this context, long-term monitoring of acrylamide levels in commercial products is essential to evaluate the effectiveness of these measures and their impact on consumer exposure. The aim of this study was to assess acrylamide levels in 60 breakfast cereals, 80 biscuits, and 65 crispbread samples marketed in Spain in 2025. Results were compared with previous studies to analyse trends related to product format, grain composition, and the use of refined versus wholegrain ingredients. Acrylamide concentrations in breakfast cereals ranged from <15 to 569 µg/kg; 95% of the samples complied with EU benchmark levels. The highest values were observed in puffed cereals and in products made from wheat and spelt. In biscuits, levels ranged from 33 to 1180 µg/kg, with 88.7% complying with EU regulation; the highest values were found in wholegrain biscuits and those made from rye, wheat, and spelt. In crispbread, concentrations ranged from <15 to 498 µg/kg, and only 1.5% exceeded the reference values. The highest levels were observed in wholegrain products, following the order: sliced crispbread > crackers > thin breads > round breads. Acrylamide content in breakfast cereals and biscuits have decreased markedly since 2006-2007, with mean values declining from 292 µg/kg to 114 µg/kg and from 424 µg/kg to 184 µg/kg, respectively. These results highlight the influence of formulation and processing on acrylamide formation and underscore the importance of continuous monitoring and targeted mitigation strategies in cereal-based foods.

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Session 2: Updates on chemistry & processing to reduce acrylamide

Acrylamide: Formation, Mechanism and Reactions

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ABSTRACT

Acrylamide is a heat-induced contaminant formed predominantly during the thermal processing of carbohydrate-rich foods via the Maillard reaction. This presentation reviews the current understanding of the chemical mechanisms governing acrylamide formation, emphasizing the central role of the amino acid asparagine and its interaction with reducing sugars such as glucose and fructose. The formation pathway involves the initial generation of Schiff bases and subsequent decarboxylation reactions, yielding key intermediates, particularly 3-aminopropionamide (3-APA), which can either directly deaminate or further react to produce acrylamide. Alternative routes, including direct β-elimination from decarboxylated Schiff bases, also contribute to acrylamide generation, with their relative importance depending on reaction conditions such as temperature, moisture, and pH (Stadler at al., 2002, Mottram et al., 2002, Zyzak et al., 2003, Granvogl et al., 2004, Stadler and Scholz, 2004).

Beyond classical sugar–asparagine systems, reactive carbonyl compounds, α-dicarbonyls, and 5-hydroxymethylfurfural (HMF) have been identified as significant contributors, often enhancing acrylamide formation under low-moisture and high-temperature conditions (Gökmen et al., 2012). The efficiency of different precursors varies widely, highlighting the importance of molecular structure and reaction environment. While the Maillard reaction remains the dominant pathway, minor and non-Maillard routes such as those involving acrolein, acrylic acid, peptides, and enzymatically generated intermediates have also been described, though their overall contribution is generally limited.

The review also discusses key factors influencing acrylamide formation, including precursor availability, food composition, processing conditions, and agronomic variables. Mitigation strategies are examined in light of these mechanisms, with approaches such as precursor reduction, enzymatic treatment (e.g., asparaginase), and process optimization showing substantial effectiveness. The FoodDrinkEurope Acrylamide Toolbox is highlighted as a comprehensive framework for industrial risk management.

Finally, the toxicological relevance of acrylamide is addressed, noting its classification as a probable human carcinogen and its neurotoxic and genotoxic properties. The reactivity of acrylamide towards amino and thiol compounds implies that acrylamide may interact with these compounds in the gastrointestinal tract, potentially mitigating the risks associated with acrylamide exposure (Mogol et al, 2026).

The review underscores the complexity of acrylamide formation pathways and the need for balanced mitigation strategies that reduce exposure while preserving desirable sensory and nutritional qualities of foods.

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A cereal manufacturer's view on acrylamide: challenges and pathways forward within the framework of BMLs and MLs

COLM CAMPION

R&D Senior Product Dev. Specialist, Cereal Partners Worldwide

ABSTRACT

Acrylamide formation in ready-to-eat breakfast cereals presents an ongoing technical and regulatory challenge, arising from the interplay between raw material variability, product design, and manufacturing conditions. From our manufacturing perspective, control is primarily associated with drying and toasting stages, where heat transfer, moisture distribution, and product geometry interact in complex and non-linear ways. This is further compounded by inherent variability in agricultural raw materials, where differences in grain composition cannot be fully standardised and may significantly influence acrylamide formation.

In parallel, the category continues to evolve, with CPW's continued focus on wholegrain content and New Products with simplified and benefit led ingredient lists in our breakfast cereals. While supporting nutritional objectives, such changes can introduce additional complexity in managing acrylamide, through their influence on formulation, precursors, and process behaviour.

At industrial scale, cereal production operates under dynamic conditions, where process stability, line rates, and routine events such as start-ups and shutdowns influence achievable control and variability.

This talk outlines how manufacturers manage acrylamide within the framework of BMLs and potential MLs, emphasising the importance of process understanding, historical data, and statistical confidence. It highlights the need to balance regulatory compliance, product quality, nutritional improvement, and supply continuity within a complex category.

ACRYLAMIDE MITIGATION IN RED LENTIL COOKIES USING FILAMENTOUS FUNGI FERMENTATION WITHIN A TARGETING ASPARAGINE REDUCTION APPROACH

KRISTÍNA KUKUROVÁ[1], ZUZANA CIESAROVÁ[1], DÁVID LÖRINC[2], TATIANA KLEMPOVÁ[2], MILAN ČERTÍK[2]

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ABSTRACT

Legumes are a popular source of plant-based proteins in novel cereal-based products. However, their high content of free asparagine may increase acrylamide formation during baking. Solid-state fermentation with filamentous fungi represents a promising approach not only for acrylamide mitigation but also for improving the overall nutritional value of legume-based ingredients through enzymatic modification of proteins and carbohydrates, partial degradation of antinutritional factors, and enhanced bioavailability of nutrients. This study evaluated selected filamentous fungi applied in solid-state fermentation as acrylamide mitigation strategies and assessed their impact on the sensory quality of model red lentil cookies.

Red lentil flour was fermented using *Mortierella alpina*, *Actinomucor elegans*, and *Umbelopsis isabellina*, and the effect on acrylamide formation during baking was determined. Pronounced strain-dependent differences were observed. The most effective reduction was achieved with *M. alpina*, resulting in approximately 80% lower acrylamide levels, followed by *A. elegans* with a reduction of about 35%. In contrast, fermentation with *U. isabellina* increased acrylamide formation to up to two-fold higher levels compared to the control. These differences are likely associated with distinct enzymatic activities occurring during fermentation.

The impact on sensory properties was generally negative, representing a limitation of the approach. Nevertheless, further work will focus on optimizing fermentation conditions and exploring post-fermentation treatments aimed at controlling undesirable enzymatic processes. Additional fungal strains will also be tested to improve both acrylamide mitigation efficiency and sensory acceptability while maintaining the nutritional benefits of fermentation.

Acknowledgement: This work was supported by the Slovak Research and Development Agency under Contract no. APVV-23-0169. Conference participation was supported by the COST Action CA21149 ACRYRED.

Impact of Air-Fryer Technology on the Formation of Heat-Induced Contaminants in Cereal-Based Biscuits

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ABSTRACT

Air-fryers are increasingly used in domestic cooking and are widely perceived as a healthier alternative to conventional ovens. However, their impact on heat-induced contaminant formation remains unclear (Li *et al.*, 2025). This study evaluated acrylamide formation in cereal-based biscuits prepared using two air-fryers with different air-distribution geometries (static- and rotating-basket models) and a conventional oven under comparable baking conditions (175 °C, 12 min). Biscuits were formulated using refined and wholegrain flours from wheat, rye, spelt, oat and pseudocereal flours from buckwheat. Acrylamide levels varied substantially by flour type and heating technology, ranging from 81 to 1320 µg/kg. The static-basket air-fryer produced the highest acrylamide (up to 1320 µg/kg), whereas the rotating-basket air-fryer yielded levels comparable to those of conventional oven baking (up to 515 µg/kg and 540 µg/kg, respectively). Buckwheat-based biscuits consistently showed the lowest contaminant levels among other cereal types. In addition, colour parameters (L*, a*, b*) based on the CIELAB system were evaluated as indicators of Maillard reaction progression, showing trends consistent with contaminant formation, highlighting the role of intensified convective heat transfer in accelerating reaction pathways (Mesias & Morales, 2017). Overall, the findings demonstrate that air-frying is not inherently safer than conventional baking, as device-specific high-intensity convective heat transfer can accelerate Maillard reaction kinetics, thereby increasing the formation of process contaminants and counteracting formulation-based mitigation strategies. These results provide new insights into the safety of emerging domestic cooking technologies and their implications for dietary exposure to process contaminants in cereal-based products.

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Session 3: Updates on molecular and breeding instruments for lowering free asparagine

FOUR YEARS OF ACRYRED WORKING GROUP 2 “AGRONOMY AND PLANT BREEDING”: PROGRESS ON KNOWLEDGE ABOUT FREE ASPARAGINE ACCUMULATION IN CEREALS

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ABSTRACT

Acrylamide represents a risk to human health due to its neurotoxicity and genotoxicity. Acrylamide is formed in a wide range of plant-derived foods during normal high-temperature cooking, and industrial processing at more than 120°C and low humidity. The main chemical process that causes the formation of acrylamide is the “Maillard cascade reactions”, which involve reducing sugars and free amino acids that are naturally present in many foods. Free asparagine content is the key factor in acrylamide formation in cereal-derived products. Therefore, breeding for low-asparagine varieties could help to minimize acrylamide-associated risks. The working group 2 (WG2) “Agronomy and plant breeding” of the COST Action ACRYRED (CA21149) aims to assess diversity of free asparagine in cereal species, considering both traditional and commercial varieties, and to identify the genotypes displaying low content of free asparagine in the grain. Further aims are related to understanding the biochemical pathways for free asparagine accumulation and identifying efficient ways for free asparagine reduction in cereal grains. Providing recommendations for breeders, farmers and food industry is a further target of WG2.

In this four years of ACRYRED, the WG2 members performed research activities around European countries to increase knowledge about the potential for decreasing free asparagine levels in the grain of cereals, considering all the factors that influence this trait, from modification of soil composition through fertilization to the use of biotechnology through genome editing. This presentation is aimed to present the progress obtained in the frame of WG2, with a focus on the goal-oriented collaboration between public research institute and private companies.

Reducing the acrylamide-forming potential of wheat, from fertilisation rates and disease control to CRISPR

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ABSTRACT

Food businesses face the prospect of the European Union setting Maximum Levels for acrylamide in food this year. Compliance would be greatly facilitated by the development of crop varieties with reduced acrylamide-forming potential. We have used CRISPR/Cas9 to knock out asparagine synthetase-2 (*TaASN2*) of bread wheat cv. Cadenza, on its own or together with a partial knockout (A and B genomes) of *TaASN1*. Mutations in the A, B and D genome *TaASN2* genes have also been produced by chemical mutagenesis and stacked to produce a total *TaASN2* knockout of cv. Claire. We have also assessed the effect of a natural deletion of B genome *TaASN2*. In field trials, the CRISPR lines show significant (up to >90%) reductions in free asparagine concentration and a concomitant decrease in acrylamide formation in heated flour, biscuits and bread, especially after toasting. These genetic approaches are being undertaken alongside experiments on fertilisation rates, especially of sulphur, and disease control, with the signalling hub through which pathogen infection induces free asparagine accumulation being elucidated in detail. The work is being conducted during a period of rapid change in regulations governing genome edited crops in the UK, culminating in the Genetic Technology (Precision Breeding) Act (March 2023), and its associated secondary legislation (March 2025). The UK started processing applications to market precision bred organisms (PBOs; GE crops with no transgene present) in November 2025. The EU is also moving to change its regulations on GE crops through the development of its New Genomic Techniques legislation. This illustrates how regulations are driving our research but also delaying its impact.

OPTIMISING FREE-ASPARAGINE DETERMINATION AND OVEN HUMIDITY TO MITIGATE ACRYLAMIDE FORMATION

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ABSTRACT

The formation of acrylamide during the baking of biscuits and crackers in a low-humidity environment can be significant and needs to be mitigated. Particular attention is required when novel food ingredients are used as alternative protein sources, such as chia seeds, because their effects are not yet well understood. There are several possible ways to do this. This study focused on mitigation through controlling the free asparagine content of the raw ingredients and introducing controlled humidity into the oven.

While selecting ingredients with low asparagine levels is a promising mitigation strategy for industrial applications, reliable analytical methods are needed to quantify it. Efforts were directed towards optimising alternative analytical approaches for quantifying free asparagine. First, extraction parameters were systematically optimised to ensure efficient recovery while minimising matrix interferences. The optimisation was performed on chia seeds and flour, which are more challenging due to their swelling nature. Secondly, LC-MS/MS conditions were refined to improve separation and detection sensitivity. Finally, the robustness and reliability of the two developed methods were assessed by comparing them. The optimised approach was then applied to various flours to evaluate the variability of asparagine across different raw materials.

Another mitigation method to reduce acrylamide formation is to introduce humidity into the oven during the baking process, which was found to significantly decrease acrylamide content. The combination of a low asparagine ingredient selection and the introduction of controlled humidity during baking constitutes an effective dual mitigation approach to limit acrylamide formation in baked products.

Genotype, environment and management effects on free asparagine content in winter rye grain

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ABSTRACT

Free asparagine (Asn) is the main precursor of acrylamide in heat-processed cereal products, but information on the factors affecting its accumulation in rye grain remains limited compared with wheat (Curtis et al., 2010; Szafrańska et al., 2025). This study evaluated variation in free Asn content in 147 winter rye grain samples representing 17 varieties grown at 16 Czech localities under organic, lower-input conventional and higher-input conventional management in the 2023 and 2024 harvest seasons. Free amino acids were extracted with deionised water assisted by sonication and quantified by UHPLC–HRMS. The effects of year, variety, locality and management intensity were assessed using ANOVA. Grain Asn content ranged from 476 to 1,498 mg kg^{-1}, with a mean of 906 ± 243 mg kg^{-1}. Harvest year was the dominant source of variation, with 2023 samples showing higher Asn content than those from 2024. After accounting for year, locality had the strongest independent effect, followed by variety, whereas management intensity had only a minor effect. These findings show that production site and variety selection are more effective tools for reducing acrylamide-forming potential in rye than changes in management intensity, and confirm the need for multi-year testing across contrasting environments before reliable variety recommendations can be made.

Keywords: Free asparagine; Rye; Acrylamide; Genotype × environment interaction; Variety screening; Management intensity

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Session 4: Acrylamide and human health

Acrylamide and Health risks: Evidence and Uncertainty

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ABSTRACT

The last risk assessments of acrylamide conducted by the European Food Safety Authority (EFSA) led to the adoption of mitigation measures at the European level, in line with the ALARA principle (As Low As Reasonably Achievable). The key steps of the risk assessment process will be outlined, from hazard identification to risk characterization, with particular emphasis on the use of the Margin of Exposure approach for substances that are both genotoxic and carcinogenic. Current levels of dietary exposure, although relatively low, are still associated with a potential concern for human health according to the regulatory framework, thereby justifying the implementation of risk management strategies aimed at reducing acrylamide levels in food. However, uncertainties remain, including the limited human relevance of animal data, inconsistencies in epidemiological evidence, potential deviations from linear dose–response assumptions at low exposure levels, and the possible contribution of endogenous formation. Coordinated efforts among academia, industry, and regulatory bodies are essential to address the existing knowledge gaps in acrylamide toxicology in humans and to develop appropriate methods for integration into the regulatory framework, ultimately enabling continuous improvement of human health risk assessment.

Concentration Targets: An ACRYRED View

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ABSTRACT

Concentration targets are an essential part of acrylamide mitigation, however their purpose is dependent upon the stakeholder. For authoritative bodies they provide a point of compliance, whereas for food operators such targets are a part of acrylamide management across supply chains. They enable an understanding of variability at points of control and whether there is a need for investigation and mitigation. For foodstuffs for which regulated limits exist, food operators need to translate them into concentrations that are meaningful for their specific operations based on their knowledge of acrylamide ranges within the products they produce, this can be complex. The ACRYRED community undertook a review of how authoritative limits are derived and subsequently used, we published an aligned view of what we consider as appropriate for acrylamide management. This presentation will discuss the background to this work and its outcome.

Poster Abstracts

P1
ANALYSIS OF THE FORMATION, IDENTIFICATION AND MITIGATION OF ACRYLAMIDE IN CEREAL-BESED FOOD PRODUCTS

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ABSTRACT

Acrylamide is a process-induced contaminant formed mainly during high-temperature processing of carbohydrate-rich foods. It is primarily generated through the Maillard reaction between free asparagine and reducing sugars during baking, roasting, and frying. Cereal-based foods such as bread, biscuits, breakfast cereals, crackers, toasted products, and cereal snacks are among the major dietary sources of acrylamide due to their high content of carbohydrates and the thermal treatments applied during processing. Because acrylamide has been classified as a probable human carcinogen, its presence in widely consumed cereal products has raised significant food safety concerns. This study provides an overview of the mechanisms of acrylamide formation in cereal-based foods, as well as current analytical approaches for its identification and quantification. Advanced analytical techniques, including liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS) and gas chromatography-mass spectrometry (GC-MS), are widely applied for sensitive and accurate detection of acrylamide in complex cereal matrices. These techniques allow reliable monitoring of acrylamide levels and support risk assessment and regulatory compliance. Furthermore, this work highlights various mitigation strategies aimed at reducing acrylamide formation in cereal products. These include optimization of processing parameters such as temperature and baking time, selection of cereal varieties with lower levels of free asparagine, modification of formulation (e.g., reducing sugar content), enzymatic treatment using asparaginase, and the incorporation of natural antioxidants or alternative ingredients. Technological approaches such as controlled fermentation and adjusted moisture conditions during baking have also shown potential in lowering acrylamide formation. Overall, understanding the formation pathways, improving analytical detection methods, and implementing effective mitigation strategies are essential for minimizing acrylamide levels in cereal-based foods. Such approaches contribute to enhancing food safety while maintaining the quality and sensory characteristics of cereal products widely consumed by the global population.

Key words: Acrylamide formation; Cereal-based foods; Maillard reaction; LC–MS/MS analysis; Mitigation strategies

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P2
EFFECTS OF SOURDOUGH ON ACRYLAMIDE CONTENT GLUTEN-FREE SORGHUM BREAD

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ABSTRACT

Three starter cultures *Pediococcus pentosaceus* SAP 4.4 (PP), *Levilactobacillus brevis* SAP 1.4 (LB), and *Weissella cibaria* SAP 8.7 (WC), isolated from sorghum grains and previously identified and characterized by our research team, were applied to evaluate the impact of lactic acid bacteria (LAB) fermentation in sourdough on acrylamide formation in gluten-free sorghum bread.

At the end of fermentation, all strains reached cell concentration of 10^8 CFU·g^{-1} and produced sourdoughs characterized by a pleasant lactic aroma. Among the tested variants, sourdough enriched with *P. pentosaceus* SAP 4.4 exerted the most pronounced effect on bread volume and specific volume in sorghum-based formulations.

The application of the three starter cultures resulted in a significant reduction in acrylamide content in sorghum bread samples, ranging from 35.4% (LB) to 72.12% (PP). The observed differences are most likely attributable to species specific metabolic activities, which may affect precursor availability and Maillard reaction pathways. In addition, LAB fermentation positively influenced other quality parameters of sorghum bread by improving sensory attributes and nutritional profile, as well as extending shelf life.

Organoleptic evaluation demonstrated improvements in overall appearance, crust and crumb color, crumb structure, aroma, and chewiness. The incorporation of sourdough significantly enhanced both taste and aroma. During storage, crumb compressibility decreased in all tested samples, although the rate and extent of firmness development varied depending on the starter culture used.

These findings highlight the potential application of selected LAB starter cultures as an effective strategy for mitigating acrylamide formation in gluten-free sorghum bread while simultaneously improving technological and sensory quality characteristics.

P3
INTERACTION OF DIETARY ACRYLAMIDE WITH GUT MICROBIOTA

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ABSTRACT

The discovery of acrylamide in a variety of commonly consumed foods, including fried potatoes, baked goods etc. underscored the prevalence of hazardous compounds in the diet. This substance is predominantly produced through the Maillard reaction. Nevertheless, acrylamide can also be produced through alternative pathways, such as the oxidative degradation of asparagine and lipid oxidation, particularly in foods that are exposed to low moisture and high temperatures (Töros *et al.,* 2026). According to the World Food and Agriculture Organization, the average intake of acrylamide through food products is 0.3-0.8 mg/kg per day, but the daily intake of fried products is significantly higher (~fivefold) among adolescents than it is in adults, who consume more than the average amount (Rajeh, 2024). The gut microbiota is essential for brain health, facilitating digestion, vitamin synthesis, pathogen defense, and immunological control. Dysbiosis in gut microbiota is associated with neurological conditions, including cognitive decline, depression, and neurodegenerative diseases such as Alzheimer's, Parkinson's, and ALS. Comprehending the determinants of gut microbiota composition is crucial, with nutrition being the most extensively researched element (Xu *et al.,* 2025). The gastrointestinal system may be vulnerable to the carcinogenic effects of acrylamide from dietary sources, while several researches present inconsistent findings (Palus, 2024). Studies demonstrate that prolonged dietary exposure to acrylamide and maize oil can enhance colorectal cancer development in mice by augmenting cell proliferation and suppressing apoptosis through the p53 gene (Zhang, 2009). Additional research indicates that acrylamide, even at concentrations present in food, does not independently induce cancer but may facilitate cancer progression when coupled with specific triggers. Experiments on mice indicated that dietary acrylamide did not influence cancer progression in xenografts of human colorectal adenocarcinoma, but demonstrated changes in gene expression associated with colorectal cancer formation (Raju *et al.,* 2013). Acrylamide's effect seems to be dose-dependent and affected by additional environmental carcinogenic variables.

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P4
ACRYLAMIDE INTAKE FROM FOOD IN MONTENEGRO: EXPOSURE ASSESSMENT AND POPULATION RISK

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ABSTRACT

Acrylamide is a process contaminant formed during the thermal processing of carbohydrate-rich foods and is recognized as a potentially genotoxic and carcinogenic compound. According to the European Food Safety Authority (EFSA), food products such as chips, coffee, and bakery items constitute the primary sources of acrylamide exposure in the general population. This study aimed to estimate dietary acrylamide intake and assess the associated risks in the population of Montenegro, with particular emphasis on differences between adults and adolescents.

The analysis encompassed five categories of food products: potato-based products, coffee and coffee products, snack foods, confectionery, and bread. Measured acrylamide concentrations (μg/kg) and average food intake data from the EFSA EU Menu national survey were used. Acrylamide intakes are reported as μg/kg body weight for both adults and adolescents.

The results indicate that the estimated acrylamide intake per meal in adults ranges from approximately 0.0002 to 0.075 μg/kg body weight, whereas adolescents exhibit intakes that are, on average, 30% higher. The 95th percentile values for estimated acrylamide intake in this study (0.03–0.04 μg/kg body weight) are substantially lower than those reported by EFSA (0.6–3.4 μg/kg). This discrepancy can be attributed to the present study's focus on individual food items, in contrast to EFSA estimates, which reflect total daily intake from the entire diet. When cumulative intake from multiple foods is considered, the estimated values (0.2 – 0.6 μg/kg body weight) approach the lower end of the EFSA range.

The greatest contribution to total acrylamide intake originates from products such as crisps, coffee, and bakery items, particularly white bread. While individual intake levels remain well below thresholds associated with acute toxic effects, cumulative daily intake may be comparable to estimated exposure levels in the broader European population. In summary, the findings suggest that acrylamide intake in the studied population does not

pose an acute health risk; however, chronic exposure, especially among younger individuals, warrants attention and the implementation of mitigation measures. The results are consistent with EFSA estimates and underscore the need for continued monitoring and control of acrylamide in food at the national level.

Key words: Acrylamide, risk assessment, dietary exposure.

P5
ACRYLAMIDE REDUCTION IN CEREALS: AROMA TRADE-OFF

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ABSTRACT

Acrylamide formation in cereal-based products such as bread, biscuits, and breakfast cereals is recognized as an important food safety issue due to its potential carcinogenic risk. In recent years, research has increasingly focused not only on reducing acrylamide levels but also on preserving sensory and aroma quality, which is essential for consumer acceptance in gastronomy.

Several mitigation strategies have been proposed. These include enzymatic treatment with asparaginase, optimization of fermentation conditions, reformulation approaches such as reducing reducing sugars and modifying amino acid composition, and the use of natural plant-derived antioxidants. In addition, novel thermal processing technologies, including vacuum baking, infrared heating, and microwave-assisted baking, have demonstrated promising results in lowering acrylamide formation.

However, recent studies indicate that many of these interventions modify Maillard reaction pathways, leading to changes in volatile compounds responsible for key aroma characteristics such as roasted, nutty, and bread-like notes. As a result, a significant trade-off often occurs between acrylamide reduction and the preservation of desirable aroma intensity and complexity.

This study highlights the importance of a dual-target approach in modern gastronomy, aiming to ensure food safety while maintaining high sensory quality. Future research should focus on integrated strategies that combine biotechnology, process optimization, and sensory analysis to achieve both reduced acrylamide formation and optimal flavor profiles in cereal-based products.

Keyword: *Gastronomy, Acrylamide, Cereal-based products, Maillard reaction, Aroma quality*

P6
EFFECT OF RICE FLOUR EXTRUSION ON PRECURSORS AND THEIR CONTRIBUTION TO ACRYLAMIDE AND 5-HYDROXYMETHYLFURFURAL FORMATION

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ABSTRACT

This study investigated the formation of Maillard reaction products in rice flour of two particle sizes (<132 μm and >132–200 μm) subjected to different extrusion conditions (barrel temperature 80°C and 120°C, and feed moisture 15% and 30%) and in a crust-like model system prepared from these flours. In the flours, reducing sugars, free amino acids, α-dicarbonyl compounds (3-deoxyglucosone, glucosone, glyoxal, methylglyoxal, diacetyl), and glycation markers (furosine, N-ε-carboxymethyllysine, N-ε-carboxyethyllysine) were quantified. 5-hydroxymethylfurfural (5-HMF) and acrylamide were determined in crust-like samples. 3-deoxyglucosone and methylglyoxal were the predominant α-dicarbonyls in both rice flour and crust-like samples. Elevated feed moisture (30%) combined with higher temperature increased 3-deoxyglucosone and furosine but reduced N-ε-carboxymethyllysine and N-ε-carboxyethyllysine in rice flour. In the crust-like model, feed moisture strongly influenced contaminant formation: 15% moisture elevated acrylamide and 5-HMF levels, while temperature primarily enhanced 5-HMF.

Keywords: Rice flour, extrusion, Maillard reaction, acrylamide, 5-hydroxymethylfurfural

This work contributes to COST Action CA21149 ACRYRED (Reduction of acrylamide exposure of the European population through mitigation strategies), supported by COST (European Cooperation in Science and Technology). The study is based on data collected during a Short-Term Scientific Mission (STSM) conducted within the scope of this Action.

P7
CHEMISTRY-GUIDED UNDERSTANDING OF ACRYLAMIDE FORMATION AND DETECTION IN CEREAL PRODUCTS: FROM REACTION PATHWAYS TO ANALYTICAL INNOVATION

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ABSTRACT

Acrylamide is a thermally generated contaminant formed predominantly in cereal-based foods through Maillard-type reactions between free asparagine and reducing sugars *(Mesias et al., 2022)*. Its formation is governed by complex chemical pathways involving Schiff base formation, decarboxylation, and fragmentation of intermediates, strongly influenced by precursor availability, water activity, pH, and thermal processing conditions. These factors make cereal matrices particularly dynamic and chemically challenging systems for both control and prediction of acrylamide levels.

Recent studies emphasize that mitigation strategies, such as reduction of free asparagine, optimization of processing conditions, and reformulation, can significantly influence acrylamide formation *(Boyaci Gunduz, 2023)*. At the same time, reliable analytical determination remains essential for monitoring and regulatory compliance. Advanced techniques such as UHPLC–MS/MS, often combined with modified QuEChERS extraction, provide high sensitivity and accuracy for acrylamide quantification in complex food matrices *(Cossu et al., 2024)*. In parallel, electrochemical sensing platforms, particularly those based on nanostructured materials and biosensing interfaces, are emerging as rapid and cost-effective alternatives, exploiting electron transfer mechanisms for detection *(Bounegru & Bounegru, 2024)*. This review integrates recent literature to highlight how mechanistic understanding of acrylamide formation can directly support both mitigation strategies and the development of innovative analytical approaches, positioning acrylamide as a model compound linking food chemistry with modern detection technologies.

Keywords: acrylamide; Maillard reaction; cereal products; electrochemical sensors; LC–MS/MS; analytical chemistry

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P8
NUTRITIONAL IMPACT AND HEALTH EFFECTS OF GLUTEN-CONTAINING CEREALS

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ABSTRACT

Gluten-containing cereals, including wheat, barley, and rye, are widely consumed staple foods that contribute substantially to global energy and nutrient intake. They provide carbohydrates, dietary fibre, B-group vitamins, and essential minerals, particularly in whole-grain form. Recent evidence indicates that regular consumption of whole-grain cereals is associated with improved cardiometabolic outcomes, including reduced risk of cardiovascular disease and improved glycaemic regulation (Reynolds et al., 2020).

However, the nutritional and health impact of gluten-containing cereals depends on processing level and individual sensitivity. Highly refined cereal products are lower in fibre and micronutrients and may contribute to excessive energy intake and metabolic imbalance. In genetically and immunologically susceptible individuals, gluten proteins (gliadins and glutenins) may trigger immune-mediated disorders such as coeliac disease, wheat allergy, and non-coeliac gluten sensitivity (Singh et al., 2021). These conditions can lead to intestinal inflammation, villous atrophy, nutrient malabsorption, and systemic symptoms.

On the other hand, whole-grain gluten-containing cereals remain an important component of balanced diets in the general population, supporting gut health and metabolic regulation. Processing techniques such as fermentation, sprouting, and sourdough production can improve digestibility and reduce antinutritional factors, enhancing nutritional quality (Zhang et al., 2022).

Overall, the health effects of gluten-containing cereals are influenced by grain type, processing methods, and individual biological response. Future research should focus on improving cereal breeding strategies, developing low-immunogenic wheat varieties, and optimizing processing technologies to enhance nutritional benefits while reducing adverse health effects.

Key words: gluten, cereals, nutrition, coeliac disease, whole grains

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P9
SELECTION AND RECOMBINATION OF TARGETED MILLING FRACTION FOR ACRYLAMIDE MITIGATION IN NEAPOLITAN PIZZA

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ABSTRACT

Free asparagine is fundamental in acrylamide formation in wheat derivatives after high temperature processing (Žilić *et al*., 2020). Therefore, the control of its levels in wheat flour represents a suitable approach to mitigate the acrylamide formation in baked foods.

In this work, milling-based approaches to reduce asparagine content in wheat flours have been exploited. Milling streams from break and reduction rolls, along with bran and shorts, were collected and analyzed for ash, protein, and asparagine content. The streams were evaluated using cumulative ash curves to assess asparagine distribution, and then recombined to produce flours with varying extraction rates and characterized by reduced asparagine content.

Afterwards, two different flours were employed to produce Neapolitan pizza samples and evaluate acrylamide formation during baking. In particular, samples were prepared according to EU Regulation (Reg. (EU) 97/2010) and baked in a wood-fired and electric oven at 495°C for 90s.

The present study demonstrated that stream recombination can be a viable milling strategy to modulate asparagine and to reduce acrylamide forming potential in baked foods; moreover, the work highlighted that acrylamide produced during Neapolitan pizza baking is affected by both the asparagine content of flour employed and by the cooking process adopted. The data obtained have been used to estimate the dietary exposure to acrylamide of the Italian population, allowing to determine a risk characterization for this toxic compound.

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P10
TARGETED DELIVERY OF ENCAPSULATED POLYPHENOL-RICH ARTICHOKE EXTRACT FOR ACRYLAMIDE MITIGATION IN CEREAL BASED FOOD SYSTEMS

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ABSTRACT

Acrylamide is a contaminant that occurs cereal-based products during high-temperature food processing through the Maillard reaction of free asparagine and reducing sugars. Although there has been a lot of mitigation studies, there is still little to offer as to successful strategies that can be used to maintain the quality of products as well as minimize the formation of acrylamide (Mesias *et al*., 2022). Natural bioactive compounds and in particular plant-derived polyphenols have been demonstrated to have potential in reducing acrylamide formation through various reaction mechanisms but are frequently hampered by their instability during food processing and uncontrolled interactions in food matrices (Becker *et al.,* 2025). The proposed study presents a new conceptual framework of the encapsulation of polyphenol-rich extracts of globe artichoke (*Cynara scolymus*) agro-industrial byproducts to be used in the specific cereal-based systems to mitigate acrylonitrile. It is supposed that encapsulation will make polyphenols more stable in preparing dough and allow their controlled release in the thermal processing steps when the formation of acrylamide is the most intense. The suggested mechanism of action entails the engagement of released polyphenols with reactive carbonyl intermediates and Maillard reaction mechanisms, which may minimize acrylamide production via carbonyl trapping, antioxidant action, and competitive reaction with major precursors (Cankaya *et al.,* 2025). This strategy seeks to balance ingredient design and thermal processing control by offering bioactive compound delivery and process-stage functionality. Moreover, the fact that artichoke byproducts are valorised fits into the principles of a sustainable and a circular economy, value-adding to agricultural residues and overcoming food safety issues. The proposed framework will offer a foundation to experimental validation in the future and interdisciplinary cooperation in the field of food chemistry, food processing, and ingredient engineering. It will help in the generation of efficient, natural, and scalable acrylamide reduction measures in food products made of cereals.

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P11
Integrating phenotyping and regulatory approaches to understand acrylamide risk in cereal crops

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ABSTRACT

Acrylamide formation in cereal-based products is a major food safety concern, primarily driven by the accumulation of free asparagine in grains and its conversion during high-temperature processing. Abiotic stresses such as drought, cold, and nutrient imbalance strongly influence asparagine levels by altering plant metabolism and nitrogen assimilation pathways (Curtis et al., 2009; Lea et al., 2007). Understanding these interactions is essential for developing effective mitigation strategies. Recent advances in high-throughput plant phenotyping, including chlorophyll fluorescence imaging, multispectral imaging, and gas exchange analysis, enable precise assessment of plant performance under stress conditions (Fiorani & Schurr, 2013). These tools provide insights into physiological processes such as photosynthetic efficiency and stress recovery, which are closely linked to metabolic regulation of amino acid biosynthesis. At the regulatory level, post-transcriptional mechanisms, and non-coding RNAs play crucial roles in controlling stress-responsive gene expression and asparagine metabolism (Meyer et al., 2012). Integrating phenotypic and molecular regulatory data offers a comprehensive framework to identify biomarkers and regulatory networks associated with acrylamide-forming potential. Bridging plant physiology, molecular regulation, and grain quality traits provides new opportunities to reduce acrylamide risk while maintaining crop productivity. Such multi-scale approaches are essential for developing climate-resilient cereal systems with improved food safety outcomes.

Keywords: acrylamide, asparagine, abiotic stress, plant phenotyping, cereal crops, post-transcriptional regulation, stress physiology

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P12
Monitoring Acrylamide Concentrations in Domestic and Imported Potato Chips Sold in Montenegro

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ABSTRACT

Potato chips, as one of the most frequently consumed snack foods, represent a significant source of acrylamide, a carcinogenic compound whose concentrations may exceed reference levels and thus pose a risk to consumer health. On the Montenegrin market, chips are widely available through both domestic production and imports from the European Union and neighboring countries, which further underscores the need for monitoring acrylamide concentrations in these products. Considering their broad availability and potential health risks, the aim of this study was to determine acrylamide concentrations in potato chips sold in Montenegro, including both domestic and imported samples. A total of 20 different samples collected from local markets as well as from products retained at customs during 2025 were analyzed. Acrylamide extraction was carried out using a three-step procedure involving fat removal, protein precipitation, and enrichment of acrylamide in the final extract, following the methodology of Vural et al. (2005). Quantification was performed using liquid chromatography with diode array detection (LC-DAD), with confirmation by LC–MS analysis, while the method was optimized and validated in accordance with the laboratory's accreditation system. The results showed that in five imported samples, acrylamide concentrations exceeded the European Union benchmark level of 750 μg kg^{-1}. The highest value, recorded in a sample imported from Serbia, reached over 1900 μg kg^{-1}, highlighting substantial variability in product quality and a potential risk to consumer health. In domestic potato chips, concentrations were generally lower compared to imported products, with only two out of eight samples exceeding the benchmark level (765 and 921 μg kg^{-1}). These findings highlight the need for continuous monitoring and the implementation of mitigation measures to reduce acrylamide content in potato chip production, ensuring consumer safety and compliance with European standards.

Key words: Potato chips, acrylamide, health risk, Montenegro.

P13
Evaluation of acrylamide content in wholegrain crackers: balancing nutritional value and chemical safety

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ABSTRACT

In recent years, consumer demand for wholegrain cereal-based products has increased relative to refined counterparts, driven by growing awareness of health and nutrition. At the same time, there is increasing interest in replacing conventional wheat with alternative cereals such as rye, aiming to develop formulations with improved nutritional profiles and enhanced bioactive potential. Although wholegrains and alternative cereals provide important health benefits, their application in high-temperature processing may promote the formation of undesirable compounds such as acrylamide, a thermally induced contaminant associated with potential health risks. To address this issue, the present study investigated acrylamide formation in crackers formulated with wholegrain wheat, spelt, oat, rye, and buckwheat flours, baked under controlled conditions (200 °C for 14 min), and compared them with refined wheat-based products. Alternative flours exhibited higher protein content (notably spelt and oat) and nearly double the dietary fibre content (wholegrain wheat, spelt, and oat) compared with refined wheat flour. However, flour type significantly influenced acrylamide formation, which was strongly dependent on thermal processing conditions. Relative to refined wheat crackers (455 µg/kg), higher acrylamide levels were observed in wholegrain wheat (600 µg/kg), spelt (478 µg/kg), and rye crackers (791 µg/kg), all exceeding the European benchmark level of 400 µg/kg for acrylamide in crackers (EC, 2017). In contrast, oat (238 µg/kg) and buckwheat (174 µg/kg) crackers exhibited lower acrylamide concentrations than refined wheat formulations. These results highlight the importance of balancing nutritional enhancement with food safety in cereal-based product development, particularly when incorporating whole grains and alternative cereals. Minimising acrylamide formation is essential for optimising baking time–temperature combinations tailored to each formulation, thereby ensuring both consumer safety and regulatory compliance.

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P14
Global Research Trends in Acrylamide Formation in Wheat-Based Products: A Bibliometric Perspective

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ABSTRACT

Acrylamide is a heat-induced processing contaminant formed predominantly through the Maillard reaction between free asparagine and reducing sugars. All major cereal-based products are affected, including wheat-derived foods such as bread, biscuits, crackers, and breakfast cereals. Due to its probable carcinogenic and neurotoxic properties, acrylamide has become a significant concern in food safety research. This study aimed to evaluate the global scientific landscape of research on acrylamide formation in wheat-based products using bibliometric analysis. A total of 462 English-language research articles indexed in the Scopus database were initially retrieved using relevant keywords related to acrylamide and wheat. Following comprehensive content screening, the final dataset was refined to 261 publications. Bibliometric analysis was conducted using the Bibliometrix package in RStudio. The first publication on this topic appeared in 2003, and the annual growth rate of publications through 2026 was approximately 17%. Food Chemistry, followed by the Journal of Agricultural and Food Chemistry, was identified as the leading journal in terms of publication output. Elena Bartkiene from the Lithuanian University of Health Sciences, Lithuania, was the most productive author with 22 publications, followed by Nigel G. Halford from Rothamsted Research, UK (17 publications), Francisco Morales from the Institute of Food Science, Technology and Nutrition, Spain (13 publications), and Tanya Y. Curtis from Curtis Analytics, UK (12 publications). Network analysis identified six distinct collaboration clusters among authors with at least two co-authored publications. Elena Bartkiene also demonstrated the highest degree of collaboration within the author networks. Lithuania, followed by the UK, showed the strongest international collaboration in this research area. Overall, these findings provide a comprehensive overview of global research trends on acrylamide formation in wheat-based products and may assist researchers in identifying influential contributors, collaboration opportunities, and future research directions.

Keywords: Asparagine; Food safety; Maillard reaction; Mitigation strategies; Scientific trends

P15
INSTRUMENTAL COLOUR PARAMETERS AS A SCREENING TOOL FOR ACRYLAMIDE IN EXTRUDED SNACKS

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ABSTRACT

Acrylamide is an undesirable food contaminant classified as a probable Group 2A carcinogen and regulated in the European Union by Commission Regulation (EU) 2017/2158. It is formed during high-temperature processing of plant-based foods and has been reported in extruded and puffed cereal and legume products. Current benchmark levels for acrylamide range from 40 to 4000 µg/kg, depending on the food category, with the strictest values applying to foods intended for infants and young children.

This study aimed to evaluate a commercial acrylamide mitigation strategy based on pH reduction and the addition of divalent Ca^{2+} ions (calcium citrate) in extruded corn snacks flavoured with carrot, spinach and beetroot. Application of the formulation resulted in a 40–60% reduction in acrylamide content. Product quality was assessed using Bakemeter Scan RG, with emphasis on dimensional characteristics and instrumental colour parameters (L*, a*, b*).

In two products, significant changes were observed in all colour parameters while remaining within consumer-acceptable limits. In contrast, in one product where acrylamide reduction was not statistically significant, only a minor, non-significant change in parameter b* was detected. These findings suggest a relationship between colour development and acrylamide mitigation efficiency.

The results indicate that instrumental colour measurement may serve as a rapid and practical screening tool for assessing acrylamide risk in extruded products, supporting both product optimisation and routine quality control.

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P16
SIDE EFFECTS OF ACRYLAMIDE ON HEALTH

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ABSTRACT

Acrylamide is a chemical compound that forms naturally in carbohydrate-rich foods during high-temperature cooking processes such as frying, baking, and roasting. It is primarily generated through the Maillard reaction between reducing sugars and the amino acid asparagine. Over the past two decades, acrylamide has raised significant public health concerns due to its potential toxic and carcinogenic effects (Kim *at al.,* 2023; Nawrot *at al.,* 2006).

This study reviews the current scientific evidence on the side effects of acrylamide on human health, focusing on its neurotoxic, genotoxic, and carcinogenic properties (Quasmi et al., 2025).

Experimental studies have demonstrated that acrylamide exposure can lead to damage in the nervous system, including peripheral neuropathy and impaired motor function. Furthermore, it has been shown to induce oxidative stress, DNA damage, and disruptions in cellular signaling pathways. Long-term exposure in animal models has been associated with an increased risk of various types of cancer, although epidemiological data in humans remain inconclusive *(Quasmi et al., 2025; Başaran et al,* 2023)

In addition to its carcinogenic potential, acrylamide may also affect reproductive health and developmental processes. The compound is metabolized into glycidamide, a more reactive epoxide that can bind to DNA and proteins, enhancing its toxic effects. Dietary intake is considered the main source of exposure in the general population, particularly through foods such as fried potatoes, coffee, and baked goods (Quasmi et al., 2025).

In conclusion, acrylamide represents a significant food safety concern, and continuous efforts are needed to reduce its formation in food products. Public awareness, improved food processing techniques, and regulatory measures are essential to minimize exposure and protect human health.

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P17
EXPLORING THE KNOWLEDGE, ATTITUDES AND PRACTICES OF YOUNG PEOPLE IN KOSOVO TOWARDS ACRYLAMIDE IN FOOD

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ABSTRACT

This study presents a brief assessment with some young people in Kosovo regarding the assessment of knowledge and health effects of acrylamide. This study involved 65 participants aged 16 to 18 years from different fields of study, including questions on basic knowledge, sources of acrylamide formation and its health effects. The results of this research showed low levels of knowledge of acrylamide, 55% of respondents indicated that they had not heard of this chemical compound, while about 61% of them had no knowledge of what the sources of acrylamide formation and its health effects were. Overall, a very low level of awareness and knowledge of young people on the risks and sources of acrylamide was observed. In conclusion of this study, we recommend the need to increase education and information for young people in Kosovo on food safety and hazardous ingredients, including acrylamide, suggesting that even at lower and secondary educational levels, more topics be included in academic programs to raise awareness and improve food consumption practices.

Keywords: Acrylamide, foods, chemical, people, education

P18
EFFECT OF SPECIES, CULTIVAR AND YEAR ON FREE ASPARAGINE ACCUMULATION IN CEREAL GRAINS AND CONSEQUENTLY ON ACRYLAMIDE FORMATION IN COOKIES

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ABSTRACT

Acrylamide is formed in grain-based foods during high temperature processing via the Maillard reaction between free asparagine and reducing sugars. Our study investigated how different cereal species, genotypes, environmental conditions, and nitrogen and sulfur fertilization affected the content of this key precursor, free asparagine, in cereal whole-grain flour and, consequently, acrylamide in cookies. In addition, grain quality parameters including protein content, starch content, gluten content, and gluten-related structural properties were analyzed to better understand their relationship with precursor availability and acrylamide formation. Two different genotypes of each species (wheat, rye, and spelt) were grown over two growing seasons (2023 and 2024) and three different fertilization treatments were used: 1) no fertilization, 2) fertilization with 100kgN/ha, 3) fertilization with N:S=100:10kg/ha. Whole-grain flours from these genotypes were used for cookies preparation. The cookies were baked at 180°C for 10 minutes. The HPLC-DAD method was used for free asparagine analysis in flour and LC/MS for acrylamide in cookies. Standard chemical methods were applied for grain quality analyses. Our results showed that the greatest dependence of the species was identified as the dominant source of variation for free asparagine, with rye exhibiting the highest content of it. The correlation and biplot analyses showed that, although free asparagine is closely linked to acrylamide formation, protein composition and structure also significantly contribute to its formation. According to the source of whole-grain flour, the mean value of acrylamide contents in cookies from both years and for all treatments follows the order: wheat cookies ≤ spelt cookies < rye cookies. Overall, results highlight the importance of creating adaptable low-asparagine genotypes of cereals, as well as a fertilization strategy to mitigate acrylamide formation.

P19
Reducing the free asparagine content of wheat grain through crop management, imaging and genetics

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ABSTRACT

Free (soluble, non-protein) asparagine concentration in wheat grain can be reduced through appropriate crop management, including ensuring sulphur sufficiency. In order to refine our advice on optimal fertilisation rates to keep asparagine concentrations low, we ran two field trials with 12 soft (biscuit) wheat varieties and different nitrogen, sulphur, potassium, and phosphorus fertiliser combinations. Our results indicated that a sulphur to nitrogen ratio of 1:10 was sufficient to prevent large increases in free asparagine, whereas withholding potassium or phosphorus alone did not cause increases in free asparagine when sulphur was applied. Multispectral measurements of plants in the field were able to predict the free asparagine content of grain with an accuracy of 71%, while a combination of multispectral, fluorescence, and morphological measurements of seeds could distinguish high free asparagine grain from low free asparagine grain with an accuracy of 86%. The acrylamide content of biscuits correlated strongly with free asparagine content and with colour measurements, indicating that agronomic strategies to decrease free asparagine would be effective and that quality control checks based on product colour could eliminate high acrylamide biscuit products. The implementation of these measures should be accompanied by the development of low asparagine wheat varieties. To that end, quantitative trait loci (QTL) controlling grain asparagine content have been sought since the discovery of acrylamide in food in the early 2000s. However, QTL that are stable across environments have proved to be elusive. We analysed data on grain asparagine content across two field trials undertaken in the UK in 2012 and 2013. Genome data were screened for the presence of the asparagine synthetase-B2 homeologue (*TaASN-B2*), which is absent from the Chinese Spring reference genome. The *TaASN-B2* deletion was shown to associate with lower grain asparagine content under conditions of sulphur sufficiency, but not under conditions of sulphur deficiency; indicating an interaction between the two. The deletion occurs adjacent to an Inga retrotransposon and was also found in some tetraploid species, indicating the probable historic origins of the deletion in progenitors of hexaploid wheats. Expression profiling of the *TaASN2* genes was further undertaken to confirm its expression patterns in grain tissue. Our results indicate that the *TaASN-B2* deletion can lower grain asparagine content in sulphur-sufficient environments. Another QTL, on chromosome 4B, was identified through the analysis of a UK soft wheat (Robigus × Claire) doubled haploid mapping population. This QTL accounted for 14.8% of the variance in a field trial where free asparagine concentrations were relatively high overall, but only 2.6% in a trial where free asparagine concentrations were lower, indicating significant QTL × environment interactions. In both trials, it was the Robigus allele that was associated with higher free asparagine concentrations.

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P20
A Food Systems Approach to Acrylamide Mitigation

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ABSTRACT

Well-known approaches for acrylamide mitigation in cereal products involve both pre- and post- farm gate strategies, whether this is developing low asparagine wheat varieties or altering ingredient formulation and processing during product manufacture. However, successful mitigation at these stages does not necessarily translate into reduced dietary intake of acrylamide as social, economic and political factors can influences the implementation and final impact of new or reformulated low acrylamide products.

In this paper, we map (borrowing social science tools) the influences across the food system considering in particular the fragility of the supply chain, the impact of new EU legislation imposing maximum limits on certain product categories, and the social drivers shaping consumer behaviour.

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