CA21149 – Reducing Acrylamide Exposure of Consumers by a Cereals Supply-chain Approach Targeting Asparagine

ACRYRED Final General Meeting PROCEEDINGS

22-23 September 2026 Aristotle University of Thessaloniki, Greece

This article/publication is based upon work from COST Action ACRYRED, CA21149, supported by COST. COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.

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ACRYRED FINAL GENERAL MEETING PROCEEDINGS

ORGANIZED BY:
Aristotle University of Thessaloniki, Greece
COST ACTION 21149 ACRYRED

EDITED BY:
Zuzana Ciesarová

PUBLISHED BY:
National Agricultural and Food Centre, Lužianky, Slovakia, 2026

Location of e-print: https://acryred.eu/activities/acryred-general-meeting-in-thessaloniki/

Slovak National Library
ISBN 978-80-69227-08-8
EAN 9788069227088

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CONTENT

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WELCOME

It is with great pleasure that we welcome you to the final General Meeting of the ACRYRED COST Action in Thessaloniki, Greece!

Hosted by the Aristotle University of Thessaloniki under the auspices of the School of Chemistry, this two-day event will showcase overviews of activities through dedicated sessions led by each Working Group, as well as poster presentations from Early Career Researchers.

We look forward to a dynamic closure to this successful and productive COST Action!

LOCAL ORGANISING COMMITTEE

Adamantini Paraskevopoulou, Aristotle University of Thessaloniki, School of Chemistry, Thessaloniki, Greece

Maria Papageorgiou, International Hellenic University, Department of Food Science and Technology, Thessaloniki, Greece

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CORE GROUP MEMBERS

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Neil Buck, *Action Vice Chair, Grant Holder Scientific Representative,* ILSI Europe a.i.s.b.l. Belgium

Małgorzata Starowicz, *Science Communication Coordinator, WG1 Co-Leader,* Institute of Animal Reproduction and Food Research, Poland

Kristina Kukurova, *Grant Awarding Coordinator,* National Agricultural and Food Centre, Slovakia

Elena Baldoni, *WG2 Leader,* IBBA-CNR National Research Council, Italy

Viktor Korzun, *WG2 Co-Leader,* KWS SAAT SE & Co. KGaA, Germany

Jane Parker, *WG3 Leader,* University of Reading, United Kingdom

Christine Nowakowski, *WG3 Co-Leader,* University of Minnesota, United States

Tanya Curtis, *WG4 Leader,* Curtis Analytics Ltd., United Kingdom

Meleksen Akin, *WG4 Co-Leader,* Igdır University, Turkey

Zuzana Ciesarova, *WG5 Leader,* National Agricultural and Food Centre, Slovakia

Vural Gökmen, *WG5 Co-Leader,* Hacettepe University, Turkey

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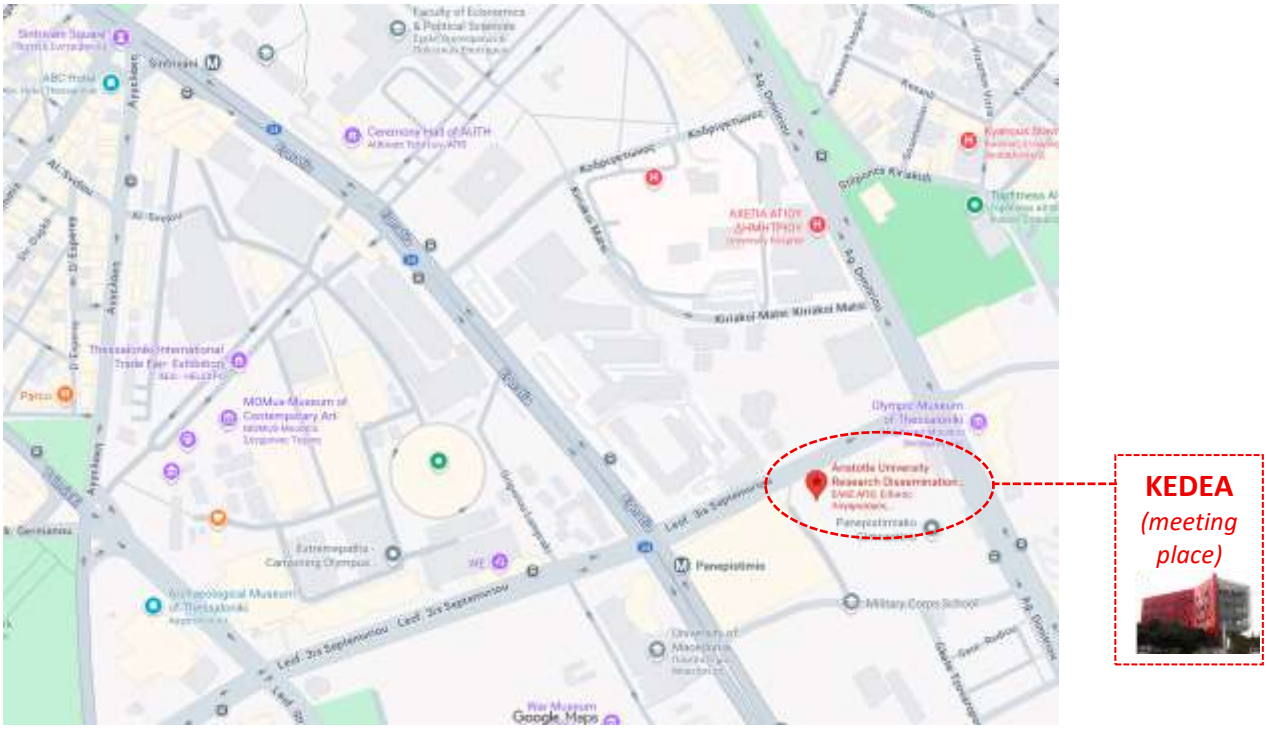
VENUE

The Meeting will take place at the **Aristotle University's Research Dissemination Center (KEDEA)**, located downtown, on Tritis Septemvriou Ave. at Aristotle University's campus between the Student Club and the University Gymnasium. An important element of the architecture of the building is the characteristic red color. The meeting will take place in amphitheaters II & III, located on the Basement level (-1).



https://maps.app.goo.gl/UHTi4YsXfRGAFdTH9

INTERNET ACCESS

Wireless internet and eduroam are available in the AUTH Campus. More information will be given during the event.

TO REACH THE CITY/VENUE

From Thessaloniki Airport "Makedonia" to the center of the city

The **airport "Makedonia"** in Thessaloniki is located 14 km out of the city. A public bus service is available 24 hours a day from the airport to the city centre and the journey takes about 40 - 50 min. Tickets cost 2 € one-way and can be bought on the bus or deducted directly from your bankcard.

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Non-stop service to and from the city centre:

- Bus Route No. 01X "KTEL – Airport"
- Bus Route No. 01N "KTEL – Airport" (Night Service)

For more information, please click below:
https://www.skg-airport.gr/en/flights--more/airport-information
https://maps.app.goo.gl/mdzfkkoysh7mqoEQ8

Taxis are also available at any time (25-30 €). A double fare is applicable between midnight and 05:00 am

Please, note that the **metro** currently does not connect the airport with the city center, but you can take the metro to reach KEDEA from various parts of the city by getting off at the "**Panepistimio**" station (https://www.thessmetro.gr/en/). If you prefer, you can also walk directly from your hotels (from 10 to 30-min walk) or take the local buses. The standard ticket for both the bus and the metro is 0.60 €.

The KEDEA building is connected with the following bus lines (https://oseth.com.gr/en/):

02K, 14A, 58 Bus Stop University of Macedonia
17, 24, 37 Bus Stop Fititiki Leschi
10, 31 Bus Stop Agia Foteini- University of Macedonia
27, 28, 83 TS Panepistimia

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PROGRAM

Tuesday, 22 September 2026

Morning – **Core Group Session 10:00 – 12:00**

- Action Chair Opening
- Core Group Session and Approval of the MC Agenda

On-line: CG meeting online

Afternoon – **Management Committee Session 14:00 – 17:00**

- Action Status – Nigel Halford
- Budget Status – Ruchi Pragnesh Shah
- WG Status and Summary of Activities - WG Leaders
- Grant Status – Kristina Kukurova
- Communication Status – Małgorzata Starowicz

On-line: MC meeting online

20:00 – Social Dinner

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Wednesday, 23 September 2026

General Session
Link for on-line participation: GM online

08:30 – 09:00	**Registration**				
09:00 – 09:05	**Introduction, Overview**				
			Nigel Halford	UK	
09:05 – 10:00	**WG1 Activities and Outcomes**				
	09:05 – 09:30	T 01	Nigel Halford	UK	Overview of the ACRYRED project and update on progress in reducing the acrylamide-forming potential of wheat using CRISPR and mutagenesis
	09:30 – 09:45	T 02	Agim Rysha	KV	Assessing Kosovo's Readiness for Current and Emerging EU Acrylamide Requirements
	09:45 – 10:00	T 03	Theo Zacharis	EL	From Network to Legacy: European Funding Pathways for Sustaining ACRYRED's Impact Beyond CA21149
10:00 – 11:00	**WG2 activities and outcomes**				
	10:00 – 10:15	T 04	Elena Baldoni	IT	Four years of ACRYRED Working Group 2 Agronomy and Plant Breeding: progress on knowledge about free asparagine accumulation in cereals
	10:15 – 10:30	T 05	Deboprio Sushmoy	DE	Dissecting genetic architecture of free–asparagine related loci in wheat
	10:30 – 10:45	T 06	Delfina Barabaschi	IT	Allelic variation analysis of asparagine synthetase in wheats for acrylamide mitigation
	10:45 – 11:00	T 07	Slađana Žilic	RS	Increased risk of acrylamide formation in bakery products as a result of susceptibility of wheat to Fusarium head blight infection
11:00 – 11:30	**Coffee break**				
11:30 – 12:30	**WG3 activities and outcomes**				
	11:30 – 11:40	T 08	Jane Parker	UK	Review of WG3: Food Chemistry and Processing
	11:40 - 11:45	T 09	Claudia Passos	PT	ACRYRED Webinars 2023-2025
	11:45 – 12:00	T 10	Tolgahan Kocadagli	TR	Utilising Cereal Sprouting to Improve Quality and Reduce Acrylamide Formation in Bakery Products
	12:00 – 12:15	T 11	Alisa Rudnitskaya	PT	Electrochemical sensor for acrylamide detection in foodstuffs
	12:15 – 12:30	T12	Christine Nowakowski	US	A Systems Approach to Acrylamide Regulation: Public Health, Markets, and Food System Resilience

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12:30 - 13:00	**WG4 activities and outcomes**				
	12:30 – 12:45	T 13	Tanya Curtis	UK	WG4 Activities: From Stakeholder Acceptability to Integrated Acrylamide Mitigation
	12:45 – 13:00	T 14	Bojin Bojinov	BG	Potential use of NGTs for decreasing acrylamide content in foods amid recent regulatory developments in the EU
13:00 – 14:00	**Lunch break and Poster Session**				
14:00 - 15:00	**WG5 activities and outcomes**				
	14:00 – 14:15	T 15	Zuzana Ciesarova	SK	Four Years of ACRYRED Working Group 5 “Risk-Benefit Analysis of Acrylamide and its Mitigation Measures”: Bridging Science, Industry and Health Perspectives
	14:15 – 14:20	T 16	Kristina Kukurova	SK	Interlaboratory Ring Tests for Acrylamide Determination in Cereal-Based Products
	14:20 – 14:30	T 17	Liliana Vargas–Murga	ES	Systematic Review of the Health Risks of Acrylamide Exposure and Mitigation Measures in Cereal–Based Foods
	14:30 – 14:40	T 18	Miguel Faria	PT	From Food Matrix to Gut: A Review of Acrylamide Bioaccessibility and Gastrointestinal Fate
	14:40 – 14:50	T 19	Tomas Podzimek	CZ	Mitigation Strategies for Acrylamide in Cereal–Based Foods: A Systematic Review of Evidence
	14:50 – 15:00	T 20	Sylvia Bucsaiová	SK	How Research Meets Reality: Translating ACRYRED Research into Practical Acrylamide Mitigation for SME Food Production
15:00 - 15:30	**Training school session**				
	15:00 – 15:05	T 21	Nigel Halford	UK	ACRYRED Training Schools: A Pan-European Capacity-Building Initiative on Acrylamide Mitigation
	15:05 – 15:10	T 22	Zuzana Ciesarova	SK	Training School on “Approach to the Assessment of Acrylamide Mitigation Measures in Cereal-Based Food Processing”
	15:10 – 15:15	T 23	Elena Baldoni	IT	Training School on “Genetics and Agronomy for Low Acrylamide-Forming Potential in Cereals”
	15:15 – 15:20	T 24	Vural Gökmen	TR	Training School on “Building Skills on the Evaluation of Acrylamide Mitigation Measures in Cereal-based Products with a Risk-Benefit Balance Approach Considering Industry Perspectives and Regulations”
	15:20 – 15:25	T 25	Kapllan Sulaj	AL	Training School on “Assessing acrylamide hazards: Strategies for risk mitigation and legislative approaches across different countries”
	15:25 – 15:30	T 26	Tanya Curtis	UK	Training School on “Integrated Strategies for Acrylamide Reduction: Connecting Agronomy, Genetics and Industry”

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15:30 - 16:10	**Mobility grant session**				
	15:30 – 15:35	T 27	Kristina Kukurova	SK	Grant Activities Supporting Collaboration and Capacity Building in ACRYRED
	15:35 – 15:40	T 28	Elena Bartkiene	LT	From STSM to Scientific Collaboration: Green Lentil Fortification of Wheat Bread and Acrylamide Formation as an Outcome of Knowledge Exchange
	15:40 – 15:45	T 29	Barbara Siegmund	AT	The investigation of shortbread of different formulations in the course of an ACRYRED STSM stay @ Graz University of Technology
	15:45 – 15:50	T 30	Magdalena Surma	PL	How fat substitutes in shortbread influence the formation of flavour and process contaminants
	15:50 – 15:55	T 31	Maria Rozanska	PL	Effect of rice flour extrusion on α–dicarbonyl compounds, protein glycation products, and the formation of acrylamide and 5–hydroxymethylfurfural in bread crust–like system
	15:55 – 16:00	T 32	Dino Hasanagic	BA	Sulphur Fertilization Effects on Acrylamide Precursor Dynamics and Grain Quality in Autochthonous Wheat Varieties from Bosnia and Herzegovina
	16:00 – 16:05	T 33	Malgorzata Starowicz	PL	Impact of Formula and Processing Technology on Acrylamide Formation and Amino Acid Composition in Bread
	16:05 – 16:10	T 34	Miona Belovic	RS	Thermal Processing Effects on Acrylamide Formation in Dry Peas (*Pisum sativum* L.)
16:10 – 16:40	**Coffee break + Poster Session**				
16:40 – 17:00	**Acrylamide MLs update:** Neil				
	16:40 – 17:00	T 35	Neil Buck	BE	ACRYRED Community Position on the Use of Benchmark and Maximum Levels for Acrylamide Risk Management
17:00 - 17:30	**Vision for future**				
	17:00 – 17:30	T 36	Nigel Halford	UK	What happens post–ACRYRED
17:30 – 17:40	**Guidelines on Reimbursement**				
17:40 – 18:00	**Closing remarks and Gratitude**				

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POSTER PRESENTATIONS

Nº	Surname	Name	WG	Country	Title
P 01	Benešová	Monika	WG3	CZ	Free asparagine distribution in wheat and rye milling fractions: Evidence from fertilization trials
P 02	Bulantekin	Özcan	WG4	TR	Determination of Some Properties of Halva Made from Kavilca and Wheat Flour
P 03	Çakmak	Selin	WG3	TR	Role of glutathione and cycteine in acrylamide metabolism during in vitro and in vivo digestion
P 04	Cebi	Aysegul	WG3	TR	Protective Effects of Lutein Against Acrylamide-Induced Ferroptosis in Human Vascular Endothelial Cells
P 05	Cunha	Sara	WG5	PT	Occurrence, Influence of Brewing Methods, and Risk Assessment of Dietary Exposure to Acrylamide in Coffee Beverages in Brazil
P 06	Dvořák	Petr	WG2	CZ	Effect of Nitrogen and Sulfur Fertilization Timing on Free Asparagine Content in Winter Rye Grain
P 07	Erdem	Naz	WG5	TR	Synthesis of acrylamide-free Maillard reaction flavours using mechanochemistry in model systems
P 08	Grahovac	Nada	WG3	RS	Development and Optimization of an HPLC-RID Method for Sugar Analysis in Plant Matrices: A Tool for Acrylamide Precursor Monitoring
P 09	Guerrini	Lorenzo	WG3	IT	3D imaging and morphology-based descriptors for supporting acrylamide assessment in baked products
P 10	Hamzalıoğlu	Aytül	WG5	TR	The Risk of Acrylamide Formation in Baby Biscuits Reformulated with Natural Sweeteners
P 11	Ilin	Sonja	WG2	RS	Assessment of Cereals for Low Free Asparagine and Acrylamide Reduction in 3D snack Products
P 12	İnce	İkbal Agah	WG4	TR	Synthesis and characterization of a new acrylamide-based antioxidant for improving thermal and oxidative stability
P 13	Kastrati	Fitim	WG2	KV	Plant phenotyping as a tool for breeding climate-resilient cereals with reduced potential for acrylamide formation
P 14	Koraqi	Hyrie	WG5	KV	Acrylamide in potato chips and bread from the Balkan market: Content and health risk assessment
P 15	Kouřimský	Tomáš	WG3	CZ	Influence of agrotechnological and environmental conditions on free asparagine content in Czech wheat grain
P 16	Laci	Lindita	WG3	AL	Acrylamide in Coffee: Sources, Health Concerns, and Future Perspectives
P 17	Mesias	Marta	WG5	ES	From Flour to Baked Products: The Role of Alternative Cereals in Nutritional Quality and Acrylamide Formation
P 18	Neškovič	Beka	WG3	RS	Soil-dependent effectiveness of sulfur fertilization in mitigating free asparagine accumulation in cereals and consequently acrylamide formation risk in cookies
P 19	Nezaj	Rozarta	WG5	AL	Reducing Acrylamide in Cereal-Based Foods: Current Mitigation Strategies, Risk–Benefit Evaluation, and Regulatory Perspectives
P 20	Nikolić	Valentina	WG3	RS	Effect of foliar sulfur application on free asparagine accumulation and acrylamide formation in maize products
P 21	Nuha	Demokrat	WG3	KV	Chemical and Processing Aspects of Acrylamide Formation and Mitigation in Cereal-Based Food Products

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P 22	Nuha	Demokrat	WG4	KV	Economic Assessment of Acrylamide Mitigation across the Cereal Supply Chain: A Case Study from the Republic of Kosovo
P 23	Pescatore	Antonio	WG2	IT	Effect of Sulphur and Selenium foliar fertilization on grain quality in bread wheat (Triticum aestivum L.)
P 24	Rakszegi	Marianna	WG2	HU	Protein and Free Amino Acid Profiles in Spelt vs. Bread Wheat: A Comparative Evaluation of Quality and Processing Potential
P 25	Satranský	Matěj	WG2	CZ	Variability of Free Asparagine Content in Naked Oat (Avena nuda) Grain: Effects of Genotype, Location, and Climatic Factors
P 26	Sensoy	Yesim	WG3	TR	Acrylamide Reduction in Potato Snacks by Adding Thiol Compounds
P 27	Shaukat	Muhammad Nouman	WG3	IT	Targeted Delivery of Encapsulated Polyphenol-rich Artichoke Extract for Acrylamide Mitigation in Cereal Based Food Systems
P 28	Spanic	Valentina	WG2	HR	Balancing Yield, Quality, and Acrylamide Risk in Winter Wheat under Variable Environments
P 29	Süfer	Özge	WG3	TR	Underexplored Traditional Turkish Foods: Filling Knowledge Gaps in Acrylamide Occurrence and Dietary Exposure
P 30	Szafrańska	Anna	WG2	PL	Asparagine distribution in commercial wheat flours produced using different milling technologies and its relation to acrylamide formation in bread
P 31	Tafuri	Andrea	WG2	IT	From Gene to Grain: A Virtual Mobility Initiative Promoting Integrated Approaches to Free Asparagine and Acrylamide Mitigation
P 32	Tas	Neslihan	WG3	TR	Acrylamide Formation in Protein-Enriched Corn Extrudates: Effects of Pea Protein, Sugars, and Processing Conditions
P 33	Yılmaz	Murat	WG3	TR	Biomass-Derived Functional Materials as Emerging Sustainable Tools for Acrylamide Mitigation in Cereal Processing: A Literature Perspective

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ABSTRACTS OF TALKS

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T 01 Overview of the ACRYRED project and update on progress in reducing the acrylamide-forming potential of wheat using CRISPR and mutagenesis

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ACRYRED's activities and impact will be summarised, and a proposal for post-ACRYRED activities presented. The current status of our work to develop low asparagine wheat varieties using CRISPR/Cas9 and TILLING mutagenesis will also be described, with an assessment of the potential of low asparagine varieties to facilitate compliance with evolving regulations on acrylamide in food. 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*. field trials, Acrylamide in bread made from the *TaASN1/2* CRISPR line grown in field trials was below detection levels, while in the *TaASN2* CRISPR line it was 14% of the Cadenza control. Even after 4 min of toasting, acrylamide levels remained at 8% and 23%, respectively, of the control. The concentration in bread made from the TILLING *TaASN2* knockout was 21% that for the Claire control, rising to 46% after 4 min of toasting. We are also elucidating the signalling hub through which pathogen infection induces free asparagine accumulation with the aim of identifying additional targets for genetic interventions. 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 and our *TaASN2* knockout line is currently moving through that process. The EU has also adopted new regulations on GE crops through the development of its New Genomic Techniques legislation. These developments are welcome, but the regulatory situation has become more uncertain recently with the UK and EU moving to align on food standards.

ACRYRED

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T 02 Assessing Kosovo's Readiness for Current and Emerging EU Acrylamide Requirements

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Background: Acrylamide is a process contaminant formed during high-temperature processing of foods such as potato products, bread, cereals, and coffee. Due to its genotoxic and potential carcinogenic properties, it is an important food safety concern in the European Union (EU). Commission Regulation (EU) 2017/2158 introduced mandatory mitigation measures and benchmark levels for reducing acrylamide in food. As a potential EU candidate, Kosovo has committed through the Stabilisation and Association Agreement, in force since 2016, to progressively align its food safety legislation with the EU acquis. However, its preparedness for acrylamide requirements has not been systematically assessed, while the EU is considering revised benchmarks and possible maximum levels.
Objective: This study assessed Kosovo's readiness to implement current and emerging EU acrylamide requirements, focusing on regulatory, laboratory, monitoring, official-control, and institutional capacities.
Methods: A qualitative assessment reviewed EU legislation, EFSA opinions, European Commission documents, Kosovo food safety legislation, and SAA-related materials, with emphasis on analytical capacity, accreditation, monitoring, and official controls.
Results: Kosovo has important elements of a modern food safety system and previous investments in public laboratory infrastructure. Key gaps remain in acrylamide-specific method validation, accreditation, proficiency testing, national occurrence data, official monitoring, and food-business awareness. The main challenge is not necessarily new laboratory equipment, but strengthening analytical, quality-assurance, regulatory, and institutional capacities. Existing infrastructure can provide a foundation, complemented by targeted investment in personnel, validation, quality assurance, reference materials, proficiency testing, and coordination.
Conclusion: Kosovo has a foundation for alignment but needs a comprehensive acrylamide monitoring and mitigation framework. Priorities should include laboratory competence, occurrence data, risk-based official monitoring, and support for food businesses. Given evolving EU policy and possible maximum levels, a forward-looking approach is needed to strengthen capacity while building on existing infrastructure.

Keywords: Acrylamide; Food Safety; European Union; Kosovo; EU Accession; Laboratory Capacity; Risk Management; Food Monitoring.

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T 03 From Network to Legacy: European Funding Pathways for Sustaining ACRYRED's Impact Beyond CA21149

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As COST Action CA21149 (ACRYRED) reaches the close of its mandate in October 2026, it leaves a mature, multi-disciplinary network spanning the whole cereals value chain, from plant breeding and free asparagine reduction through processing, toxicology, risk assessment and consumer communication. Four years of coordinated work have produced shared analytical capacity (including interlaboratory ring tests), mitigation guidance, systematic reviews and an active Early Career Researcher community. The strategic question at the final General Meeting is not only what ACRYRED achieved, but what survives it.

COST Actions are designed to build networks, not to fund their continuation. Without a deliberate legacy plan, the assets a network accumulates disperse once the final Grant Period ends. This contribution applies a Post-Action Sustainability lens, following the "From MoU to Legacy" logic, to map ACRYRED's outputs onto concrete European funding instruments, so the evidence base becomes the foundation of a successor pipeline rather than a closed archive.

Three complementary pathways are proposed. Horizon Europe Cluster 6, under the Farm to Fork destination, provides the home for a full successor consortium: its 2026–2027 work programme, adopted in December 2025, carries an indicative budget of roughly €1.25 billion. The co-funded European Partnership on Safe and Sustainable Food Systems (SFS) offers a longer-horizon vehicle, structured for continuity rather than a single call. Finally, a science-to-policy route feeds ACRYRED's evidence into the EU acrylamide maximum-levels process and EFSA risk work, keeping the network relevant to regulation, while EIT Food channels open the way to industry uptake and product reformulation.

Mapped against these instruments (Table 1), ACRYRED's four years translate into a structured roadmap: a sustained science-to-policy and innovation pipeline on acrylamide reduction that outlives the Action itself. This approach aligns directly with the meeting's "Vision for the Future" session and offers a replicable model for how food-safety COST Actions can secure their legacy.

Table 1. Mapping of ACRYRED assets to European funding pathways [Calibri size 10]

ACRYRED Output	Funding Pathway	Time Horizon
Value-chain evidence base	Horizon Europe Cluster 6 (Farm to Fork)	Medium term
Network continuity	Safe & Sustainable Food Systems (SFS) Partnership	Long term
Regulatory evidence	EU acrylamide maximum-levels process / EFSA	Ongoing
Industry reformulation	EIT Food	Medium term

Acknowledgments: This contribution is based upon work from COST Action CA21149 (ACRYRED), supported by COST (European Cooperation in Science and Technology). www.cost.eu

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T 04 Four Years of ACRYRED Working Group 2 "Agronomy and Plant Breeding": Progress on Knowledge about Free Asparagine Accumulation in Cereals

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Acrylamide represents a risk to human health due to its neurotoxicity and genotoxicity. 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 these 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. In this presentation, the state of the art and the perspectives of the strategies aimed at reducing free asparagine content in cereals through agronomic, genetic and biotechnological approaches will be showed. In addition, the progress obtained in the frame of WG2, with a focus on the goal-oriented collaboration between public research institute and private companies, will be reported. The research activities performed by the WG2 members show that the integration of sustainable agronomic practices, innovative plant breeding, and biotechnological techniques can contribute to the development of healthier cereals with reduced acrylamide-forming potential. This approach represents the key point of the research of the next years in agronomy and genetics, aimed at reducing free asparagine content in cereals.

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T 05 Dissecting genetic architecture of free-asparagine related loci in wheat

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Wheat (*Triticum aestivum*) is the most widely cultivated cereal crop in the European Union (EU) accounting for approximately 17.5% of total global wheat production (USDA, 2025/2026). Bread wheat or hexaploid wheat plays a significant role in human diet for daily consumption as food products including breakfast cereals, breads, biscuits and pastries. However, industrial processing such as baking, frying or roasting for producing wheat-based food products can form acrylamide (C_3H_5NO), a probable human carcinogen (Group 2A) (IARC, 1994). Acrylamide formation is a part of Maillard cascade reactions involving free (soluble, non-protein) asparagine ($C_4H_8N_2O_3$) reacting with reducing sugar (Baldoni et al., 2026). Free asparagine concentration in wheat varieties is an important determinant of acrylamide formation. The content of free asparagine is highly variable in wheat varieties indicating genetic determinants of the traits. Moreover, the genetic architecture of this trait is very complex controlled by multiple loci and strongly influenced by environment and management factors. Previous studies described the genetic nature of the free asparagine trait in wheat and identified multitude of associated genomic regions by GWAS and QTL mapping (Baldoni et al., 2026). A recent study utilized metabolomics data and large-scale multi-environment trials to uncover unknown loci and candidate genes in a diverse wheat germplasm (Tafuri et al., 2025). Most studies used single SNP marker effects using linkage mapping or association mapping to identify loci related to free asparagine content in wheat. However, recent advancement in haplotype mapping approaches showed the potential benefits of identifying superior haplotypes instead of relying on single markers for better understanding the nature of complex traits (Vo Van-Zivkovic et al., 2025). This study proposes to utilize phenotypic and genotypic data sets in haplotype-based association studies to find the genomic regions associated with reduced free ASN concentration. Also, co-locating haplotypes with already identified low asparagine QTLs for better understanding of the trait. The resulting haplotype atlas would support the deployment and stacking of favourable alleles to develop wheat cultivars with reduced acrylamide forming potential while maintaining agronomic performance.

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T 06 Allelic variation analysis of asparagine synthetase in wheats for acrylamide mitigation

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Free asparagine serves as a crucial nitrogen transport and storage molecule in plants, accumulating notably under stress conditions. However, during high-temperature processing of cereal-based products, it acts as the primary precursor for acrylamide (C_3H_5NO), a carcinogenic contaminant [1]. Minimizing asparagine accumulation in wheat grain is therefore a public health priority. Asparagine biosynthesis is catalyzed by asparagine synthetase, encoded in *Triticeae* by a multigene family. Notably, a natural deletion of the *TaASN-B2* gene on the B genome has been linked to lower free asparagine content, although this effect can be mitigated by biotic and abiotic stresses [2].
Within the framework of the PRO-MITIGATION ON FOODS project, previously developed PCR assays were utilized to screen for the presence/absence of this key deletion across an extensive and well-characterized wheat germplasm with diverse ploidy levels (*Triticum aestivum* – 6X and *T. durum* – 4X), available at CREA-GB. This comprehensive screening included a collection of modern Italian soft and durum wheats, alongside the *Ta-ssp* panel—a diverse hexaploid wheat collection encompassing cultivars, landraces, and wild genotypes of global origin and belonging to different ancient *aestivum* subspecies [3]. The molecular analysis revealed substantial allelic variability, demonstrating that the frequency of the *TaASN-B2* deletion is highly dependent on the specific wheat species and subspecies. Given the extensive agronomic, phenotypic, and genetic data already available for these materials, identifying ancient accessions carrying this deletion provides a powerful starting point for deeper investigations into asparagine regulation. Furthermore, seed samples collected from multiple experimental years are available for these accessions, offering a unique opportunity to quantify free asparagine content across different environmental conditions**.** Consequently, new segregating populations are currently being developed from these selected genotypes. These promising genetic resources will serve as the foundation for future research aimed at dissecting the mechanisms of asparagine accumulation and accelerating the breeding of low-acrylamide wheat cultivars.

Acknowledgments: This work was conducted as part of the PRO-MITIGATION research project "SPOKE 4 ONFOODS" "Research and innovation network on food and nutrition Sustainability, Safety and Security – Working ON FOODS"

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T 07 Increased risk of acrylamide formation in bakery products as a result of susceptibility of wheat to Fusarium head blight infection

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Wheat is one of the most important cereal grains providing carbohydrate staple foods that form the basis of most diets around the world. However, wheat production is endangered by Fusarium species which cause Fusarium head blight (FHB). Fusarium head blight is one of the most devastating diseases of small grain cereals which not only causes grain yield losses, but also decreases wheat quality. In addition, Fusarium infection of wheat can potentially elevates the risk of acrylamide formation in baked products by drastically increasing the concentration of free asparagine and reducing sugars in grains. For this reason, these investigations focused on the detection of sugars and free asparagine changes in flour of bread wheat varieties under natural infection and Fusarium artificial inoculation. Field research was conducted during 2023–2024 with six winter wheat varieties that vary from being resistant to very susceptible to FHB. General (disease severity) and Type I resistance of genotypes to natural infection and Fusarium artificial inoculation were evaluated, and the content of sugars, total free amino acid and free asparagine in the grains was determined. Variety Tika Taka exhibited the highest disease severity (low general resistance), while the highest type I resistance was observed at variety Vulkan. Although there was a slight increase in the content of fructose in the flour of most of the FHB stressed varieties compared to naturally infected samples, it was not statistically significant except in the variety Tika Taka. In stressed flour of this variety, the increase in content amounted to 17%. In the FHB inoculated flour of this most sensitive variety, glucose significantly increased by 25% compared to the corresponding naturally infected flour. Overall, statistically significant increase in the total free amino acid content was accomplished by varieties El Nino (19%) and Tika Taka (46%) in the flour from Fusarium treatment, compared to naturally infected flour. The highly resistant variety Vulkan had the significant decrease by 16%. As far as free asparagine is concerned, this amino acid was also significantly increased in the flour from Fusarium inoculation of all tested genotypes compared to natural infection, except for the Vulkan. Variety Vulkan, which showed the highest resistance, had the lowest amount of asparagine in both treatments. The highest increase was about 51% for Tika Taka. Our results indicate that wheat breeders may have an opportunity to reduce free asparagine concentration in the grain by identifying and selecting genotypes carrying FHB resistance, as well as that proper application of agrotechnical measures aimed at disease prevention can influence the content of acrylamide precursors in the grains and reduce the health risk in bakery products.

Acknowledgments: This research was supported by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia (Grant No. 451-03-33/2026-03/200040), the European Union—NextGenerationEU and COST Action CA21149.

T 08 Review of WG3: Food Chemistry and Processing

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WG3 comprised >270 members (130 young researchers) from 32 countries, of which 25 were European and 15 of these ITCs. WG3 programme was driven by early townhall meetings and led to a **co-authored review** (25 WG3 members) of relationships between raw material composition and final product quality, including acrylamide, flavour, texture and colour, novel processing technologies to reduce acrylamide formation in cereal-based foods and rapid methods for measuring free asparagine in cereals and acrylamide in cereal-based products. Particular **gaps in the literature** were identified in associated changes in sensory quality, due attention to processing contaminants during development of new products fortified with new and alternative sources of protein, and the translation of laboratory-based solutions to pilot and manufacturing scales.

Special Issue

A Special Issue was commissioned to cover research on acrylamide, focussing on the processing of cereal-based foods and snacks. It starts with an overview of agronomic, genetic and biotechnological approaches to lower free asparagine (1), and then explores mitigation strategies including reformulation with sustainable ingredients (2–10), enzymatic interventions (11), and processing approaches (12–15), both independently and in combination. It also considers the associated challenges and risks of these interventions, including the need to balance food safety and nutrition (16) and the impact of reformulation over the past 20 years (17). The final paper (18) takes a food systems approach to investigate the impact of acrylamide regulations on the competitive structure of the grain market. Fifteen of these papers were contributed by ACRYRED members, seven of which were from Inclusiveness Target Countries (ITCs), with three further papers in progress.

Webinars

A series of five well attended **webinars** was led by Claudia Passos, pairing junior and senior researchers to discuss a range of topics and compiled as an online E-book.

Research Strategy

The WG3 strategy to build a **research agenda for the field** was initiated at the Zagreb MC2 meeting, with ideas brainstormed using a Miro board. This was followed by consultation with industry partners, contribution to the development of a white paper on the EU Commission's proposed introduction of maximum levels, and has culminated in the development of a food systems approach to reduce dietary acrylamide.

Conclusion

Reducing dietary intake of acrylamide, our ultimate goal, is a complex process that may start with reducing asparagine in grain (WG2) and/or mitigating acrylamide formation during processing (WG3/5), but is ultimately driven by social and political forces. Consumer perceptions of product quality, willingness to accept new formulations and perceptions of risk must be balanced against the need for a robust supply chain, the testing and traceability associated with implementing maximum limits, and the potential impact of regulation on the competitive structure of the food industry.

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ACRYRED Special Issue in Food Chem X 2026
Jane K Parker, Christine Nowakowski, Claudia Passos (Editors)

1. Baldoni et al: Agronomic, genetic and biotechnological approaches to lower free asparagine content in cereals: state of the art and perspectives
2. Hassani et al: Mitigating acrylamide formation using agrifood waste materials: A concise review
3. Sani et al: Reducing acrylamide in bread with plant additives: A systematic review
4. Navruz-Varlı et al: What do we know about acrylamide levels in rice and rice products? A general overview
5. Starkute et al: Green lentil fortification of wheat bread: A strategy for quality improvement and acrylamide reduction
6. Stranig et al: Flavour formation in the coffee substitute 'lupin coffee' related to the formation of acrylamide
7. Hradecka et al: Salty crackers enriched with cricket (*Acheta domesticus*) powder: A comprehensive quality and safety assessment study
8. Fathabad et al: Effects of jujube and barberry extracts on the acrylamide formation in French fries in deep fryers and microwaves
9. Hind El Hadri et al: Variations in acrylamide content of homemade biscuits with the addition of chia (ground seeds and flour)
10. Žilić et al: Effect of alternative sweeteners on acrylamide, HMF and color formation in whole-grain wheat cookies
11. Musa et al: Mitigation of acrylamide in cookies and crispbread using calcium salts, phenolic acids, and rosemary extract in combination with asparaginases
12. Guarino et al: Tailoring the formulation of wholemeal wheat flour: the selection and recombination of milling fractions to control acrylamide and deoxynivalenol contamination
13. Swiacka et al: How drying methods and carrot varieties influence the acrylamide formation in carrot-enriched breads?
14. Göncüoğlu Taş et al: Effect of extrusion parameters and feed composition on physical characteristics, aroma profile and acrylamide content in pea protein-enriched corn extrudates
15. Różańska et al: Effect of rice flour extrusion on α-dicarbonyl compounds, protein glycation products, and the formation of acrylamide and 5-hydroxymethylfurfural in bread crust-like system
16. Mesias et al: Balancing nutrition and safety: Acrylamide and HMF in biscuits from different cereal flours
17. Mesias et al: Two decades of monitoring acrylamide in breakfast cereals: impact of market reformulation and compliance with EU regulation
18. Nowakowski et al: The impact of acrylamide regulations on the competitive structure of the grain market.

Together, these papers provide a comprehensive view of current mitigation strategies and emerging challenges, reflecting the collaborative work of ACRYRED members across Europe.

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T 09 ACRYRED Webinars 2023-2025

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A series of five seminars was organized over a three-year period within the framework of COST Action CA21149, "Reducing acrylamide exposure of consumers by a cereals supply-chain approach targeting asparagine" (ACRYRED). This presentation aims to share the experience gained from coordinating this activity over three years, highlighting the organization and implementation of the seminars, as well as the collaboration established among the ACRYRED Working Groups. The activity was developed with the support of the WG3 Leaders and the active participation of members from WG2, WG3, and WG5. Each seminar followed a common structure, with a chairperson selected according to the topic under discussion, followed by a 15-minute presentation by an early-career researcher and a 15-minute presentation by a senior researcher from another organization. The seminars were open to the entire ACRYRED community, providing a platform for researchers at different career stages, from different organizations and with diverse scientific backgrounds, to exchange knowledge and engage in discussion. This format contributed to fostering interdisciplinary interaction and strengthening connections within the ACRYRED community.
Beyond their scientific and technical content, the seminars proved to be an effective dissemination and networking tool, promoting knowledge exchange, collaboration, and broader engagement with the objectives and outcomes of the ACRYRED COST Action. The experience highlights the value of structured, interactive scientific events in connecting researchers across disciplines and career stages within an international research network. Finaly, under the scope of a Virtual Mobility grant, the webinar information was translated into an E-book.

Fig.1. Webinars E-book [1].

Acknowledgments: A special thanks to all enthusiastic participation of invited authors in all performed lectures.

Reference:
[1] https://acryred.eu/news/webinar-e-book/ (accessed on 08.09.2026).

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T 10 Utilising Cereal Sprouting to Improve Quality and Reduce Acrylamide Formation in Bakery Products

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Sprouting is an effective bioprocessing tool for cereal-based foods because it simultaneously alters nutritional, technological, and sensory properties via endogenous enzymatic activity. Hydrolysis of starch and proteins increases the levels of reducing sugars and free amino acids, creating a precursor pool that intensifies the Maillard reaction during baking. These compositional changes may also increase the levels of thermal-processing contaminants. Although the amount of free asparagine initially decreases during controlled sprouting, the increase in reducing sugar levels may promote acrylamide formation if sprouting conditions, formulation, and processing are not carefully optimised. Therefore, the successful application of sprouting requires balancing flavour development with food safety.

It was demonstrated that this balance can be achieved by combining sprouting with complementary bioprocessing strategies. Controlled sprouting, targeted asparaginase treatment, and yeast fermentation effectively reduce acrylamide precursors. Furthermore, sprouted cereals can serve as natural substrates for producing Maillard reaction flavourings to restore baked aroma in low-thermal-load bakery products. Consequently, sprouted cereals enhance desirable quality attributes, including browning, baked aroma, and flavour complexity, by increasing the formation of Strecker aldehydes and other aroma-active Maillard reaction products.

This presentation summarises our research over the past five years on the use of sprouted cereals to improve bakery products and on the development of novel cereal-based ingredients for flavour enhancement and acrylamide mitigation. Overall, cereal sprouting is a versatile bioprocessing tool that can enhance the quality and safety of bakery products.

Acknowledgements: This study was funded by the Scientific Research Projects Coordination Unit of Hacettepe University (Project No: FOA-2023-20344).

T 11 Electrochemical sensor for acrylamide detection in foodstuffs

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A single-sensor electronic tongue for rapid detection of acrylamide has been proposed. The method is based on the electropolymerization of acrylamide in acidic media on single-walled carbon nanotube–modified screen-printed electrodes. Cyclic voltammetry and electrochemical impedance spectroscopy were used to characterise interfacial processes dependent on the acrylamide concentration. Electrochemical impedance spectroscopy showed that rising acrylamide concentration increased the double-layer capacitance and decreased the charge-transfer resistance, with the largest changes occurring at low frequencies, confirming impedance as a sensitive analytical signal for quantification. Two calibration strategies were compared: a univariate model based on constant-phase-element capacitance and a multivariate model based on full impedance spectrum. Both models showed a working range of 0–20 µmol/L acrylamide and comparable accuracy; however, the multivariate model had a lower detection limit of 0.48 µmol/L, versus 1.1 µmol/L for the univariate model, and improved selectivity against sucrose interference (Table 1). Since EU benchmark levels for acrylamide in grain-based products correspond to 0.84–2.8 µmol/L in aqueous extracts, the multivariate impedance approach proved better suited for real-sample screening. These results show that impedance-based sensing of acrylamide can reliably detect and quantify acrylamide at regulatory-relevant concentrations, offering a rapid, low-cost alternative to chromatographic methods for food safety screening.

Table 1. Comparison of analytical figures of merit of calibration models calculated using capacitance (univariate) and impedance modulus (multivariate).

	Univariate	Multivariate
Sensitivity	0.74	0.29
Selectivity	0.67	0.88
LOD, µmol L^{-1}	1.1	0.48
RMSEC	0.97	0.27
RMSEP	1.2	1.2

Acknowledgments: P.M.C. thanks the financial support of the ACRYRED Cost Action (CA21149) through STSM. A.R. thanks the financial support of CESAM by FCT/MCTES (UID/50017/2025, DOI 10.54499/UID/50017/2025, and LA/P/0094/2020, DOI 10.54499/LA/P/0094/2020). C.P. thanks the financial support of LAQV-REQUIMTE (UID/50006/2025, DOI 10.54499/UID/50006/2025).

T 12 A Systems Approach to Acrylamide Regulation: Public Health, Markets, and Food System Resilience

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European efforts to reduce dietary acrylamide exposure have important implications beyond their immediate public health objectives. Previous research examined how increasingly stringent acrylamide regulations could reshape the competitive structure of the European grain market. Because compliance may require access to low-asparagine wheat, additional testing, traceability systems, and changes in sourcing and production, these requirements can impose disproportionate costs on small and midsized manufacturers. Larger firms are better positioned to absorb these costs, develop dedicated supply relationships, and invest in testing and mitigation infrastructure. As a result, regulations intended to improve food safety may unintentionally contribute to market consolidation, reduce producer diversity, and create new barriers to entry within grain-based food markets.
Building from this work, we are now expanding the analysis beyond market structure to examine acrylamide regulation as a broader food systems problem. Rather than treating acrylamide primarily as a toxicological or food processing issue, current research explores the relationships among public health evidence, agricultural production, mitigation strategies, consumer risk perception, regulatory decision-making, market structure, and food system resilience. The literature points to several tensions: uncertainty in the human epidemiological evidence, evidence that existing mitigation strategies have already reduced acrylamide levels in some food categories, agricultural trade offs involved in reducing free asparagine, and differences between scientific and public understandings of chemical risk. Using systems-thinking methods, this research will ask if the regulatory conversation has drawn the boundaries of the acrylamide problem too narrowly and what consequences become visible when regulation is evaluated across the wider food system.

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This article/publication is based upon work from COST Action ACRYRED, CA21149, supported by COST. COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.

T 13 WG4 Activities: From Stakeholder Acceptability to Integrated Acrylamide Mitigation

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Working Group 4 (WG4) of COST Action ACRYRED (CA21149) examines the acceptability of acrylamide risk and mitigation from producers to consumers, with particular attention to technical efficacy, economic feasibility, product quality, supply-chain implementation and stakeholder acceptance. This report consolidates WG4 activities across stakeholder research, awareness raising, scientific dissemination, training, strategic planning and practical mitigation development.

Two questionnaires were developed for industry and the public. The public questionnaire received 109 responses, mostly from the United Kingdom, and identified substantial awareness gaps: 60.6% of respondents were unaware of acrylamide in food, 71.6% did not know what acrylamide is, 66.1% had taken no measures to reduce exposure and 98% supported further public education. Outreach to 50 companies generated no industry questionnaire responses, leaving industry attitudes as an evidence gap and indicating the need for revised engagement methods.

WG4 dissemination included LinkedIn campaigns, scientific and industry presentations, a training-course concept for breakfast-cereal manufacturers and the ACRYRED Bulgarian Training School. Strategic outputs included Deliverable 4.2 and a five-year, farm-to-fork framework linking upstream precursor control, product-specific processing, harmonised surveillance, corrective action and consumer communication. The strategy incorporates conventional and organic pathways and addresses uneven awareness, limited cross-country comparability, fragmented implementation, SME capability constraints, weak incentives for low-asparagine breeding and regulatory readiness.

Overall, WG4 has progressed from defining stakeholder-acceptability criteria to developing evidence-led, proportionate and implementation-focused approaches. Future priorities include **strengthening EU-wide participation, improving industry engagement, harmonising datasets and analytical quality, supporting farmers and SMEs, encouraging low-precursor varieties, and evaluating mitigation outcomes through measurable indicators. This integrated approach positions stakeholder acceptance as central to translating acrylamide science into effective action across the European food chain.**

Keywords: acrylamide; stakeholder acceptability; risk communication; mitigation; farm-to-fork; consumer awareness; food supply chain; ACRYRED

Acknowledgement. This work is based upon activities from COST Action ACRYRED, CA21149, supported by COST (European Cooperation in Science and Technology). The authors thank the WG4 contributors, collaborators, speakers and Training School participants.

T 14 Potential use of NGTs for decreasing acrylamide content in foods amid recent regulatory developments in the EU

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Based on the existing legal framework (Directive 2001/18 and related Regulations of the EU) and the progress of the proposed Regulation of the New Genomic Techniques a presentation of the current state and future perspectives for the use of NGTs for decreasing acrylamide content in foods will be presented. To facilitate the understanding of the actual pathways of implementation several use cases will be presented and discussed.

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T 15 Four Years of ACRYRED Working Group 5 "Risk-Benefit Analysis of Acrylamide and its Mitigation Measures": Bridging Science, Industry and Health Perspectives

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The Working Group 5 (WG5) of the ACRYRED COST Action CA21149 was established to facilitate dialogue on the health risks and benefits associated with Maillard reaction products, particularly acrylamide, and on the impact of mitigation measures applied in cereal-based foods. Over four years, WG5 evolved from **26 members from 11 countries** to a multidisciplinary network of more than **100 participants representing 28 countries** and bringing together expertise from food chemistry, toxicology, food processing, risk assessment, analytical sciences, industry and regulatory sectors.

WG5 activities included regular meetings, webinars, dissemination events and two international training schools organized in Bratislava (2023) and Ankara (2024), providing interdisciplinary training for early-career researchers, food technologists and food business operators. Major outputs included an overview of European research activities in the field of health impacts of Maillard reaction products and the development of a strategic research agenda defining future research priorities.

A distinctive feature of WG5 was its strong **engagement with industry**. In collaboration with WG4, a survey among food business operators was launched to collect information on mitigation measures currently applied in practice and to identify implementation barriers and knowledge gaps. The working group also established collaboration with SME manufacturers, creating a platform for dialogue between researchers, industry stakeholders and regulatory bodies. This interaction provided valuable feedback on the practical feasibility of mitigation measures, ingredient selection, product formulation, regulatory challenges and future needs for updates of the Acrylamide Toolbox.

WG5 additionally contributed to **analytical harmonisation** through two international interlaboratory ring tests organized by the National Agricultural and Food Centre (NPPC), involving laboratories from Europe and neighbouring regions. These exercises improved comparability of acrylamide data and strengthened quality assurance practices within the ACRYRED network.

Currently, WG5 is focusing on the preparation of **comprehensive systematic reviews** addressing health risks of acrylamide exposure, bioaccessibility and gastrointestinal fate of acrylamide, and the effectiveness of mitigation measures in cereal-based foods. These reviews are expected to become one of the major scientific legacies of WG5 and provide an evidence base for future risk assessment, regulatory decision-making and industrial practice.

The work of WG5 demonstrated that successful acrylamide mitigation requires balancing food safety objectives with nutritional quality, sensory properties and consumer acceptance, thereby supporting sustainable and evidence-based strategies for cereal-based foods.

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T 16 Interlaboratory Ring Tests for Acrylamide Determination in Cereal-Based Products

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Within the framework of the ACRYRED project, two interlaboratory ring tests focused on the determination of acrylamide in cereal-based products were organized by the National Agricultural and Food Centre (NPPC), Slovakia. The first round, implemented in 2025, was supported by a Virtual Mobility Grant and involved six laboratories from five European countries. Participants analysed two homogenised cereal samples using mainly LC-MS/MS, UHPLC-MS/MS and GC-MS methodologies.
Building on the successful implementation of the first exercise, a second ring test was conducted in 2026 and attracted considerably broader international participation. A total of 18 laboratories from Europe and neighbouring regions registered for the study, representing universities, research institutions, official control laboratories and private analytical facilities. Two homogenised cereal-based products were distributed as test materials: an organic popped rice cake and an organic extruded corn snack. Eleven laboratories reported analytical results, predominantly obtained using liquid chromatography coupled with mass spectrometry.
The results obtained in both rounds demonstrated the capability of participating laboratories to determine acrylamide in cereal matrices and provided valuable information on interlaboratory variability, method performance and measurement uncertainty. The ring tests enabled participating laboratories to benchmark their analytical procedures, identify potential sources of variability and strengthen quality assurance practices. Furthermore, the activities fostered collaboration among partners and stakeholders involved in food contaminant analysis across the ACRYRED network.
The organization of these two ring tests represents an important contribution of NPPC to capacity building and methodological harmonisation within the project. The outcomes provide a basis for further collaborative activities and support the generation of reliable and comparable analytical data among laboratories engaged in acrylamide monitoring and mitigation research.
Keywords: ACRYRED, interlaboratory comparison, ring test, acrylamide determination, cereal products, analytical harmonisation, quality assurance.

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T 17 Systematic Review of the Health Risks of Acrylamide Exposure and Mitigation Measures in Cereal-Based Foods

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Background: Acrylamide is a process-induced contaminant formed mainly during high-temperature processing of carbohydrate-rich foods, particularly cereal-based products. Due to its toxicological relevance and widespread dietary exposure, a systematic synthesis of evidence is needed to clarify potential health risks and evaluate mitigation strategies.
Objective: This systematic review aims to assess the potential health risks associated with acrylamide and glycidamide exposure from cereal-based foods across *in vitro*, animal, and human evidence streams. Additional objectives are to evaluate bioaccessibility and bioavailability of acrylamide from cereal-based matrices and to synthesize evidence on mitigation measures, including their effectiveness and possible effects on product quality.
Methods: The protocol was registered in PROSPERO (registration number: CRD420261326726). The review follows PRISMA-P principles and was conducted in CADIMA using predefined eligibility criteria. Searches were performed in PubMed, Scopus, and Web of Science for studies published between 2000 and 2026. For the health-risk domain, 12,432 titles and abstracts were screened, followed by 1,362 full texts, resulting in 1,008 papers included in the data-extraction dataset. For the mitigation-measures domain, 1,736 records were initially identified; after title and abstract screening, 198 records proceeded to full-text assessment, and 174 studies were included for data extraction. Study selection was performed independently by two reviewers, with disagreements resolved by consensus or consultation with a third reviewer. Extracted data include study design, population or test system, exposure or intervention characteristics, comparator, outcome category, dose-response information, statistical significance, and, for mitigation studies, absolute or relative reduction in acrylamide levels and reported effects on product quality.
Results: Data extraction and structured evidence mapping are ongoing. Health-risk evidence will be synthesized separately across *in vitro*, animal, and human studies and grouped by outcome categories, including genotoxicity, neurotoxicity, carcinogenicity, reproductive toxicity, metabolic and cardiovascular effects, oxidative stress, and related mechanistic endpoints. Mitigation evidence will be synthesized according to mitigation strategy, cereal-based food category, and reported acrylamide reduction.
Conclusion: This review will provide a transparent and methodologically structured synthesis of evidence on acrylamide-related health risks and mitigation measures in cereal-based foods, supporting future risk assessment, regulatory considerations, and food-processing strategies aimed at reducing consumer exposure. In addition, it will identify key knowledge gaps where evidence remains limited and offer a comprehensive analysis that reflects perspectives from both the food industry and the HoReCa sector.
Acknowledgments: This research was supported by the COST Action CA21149 Reducing acrylamide exposure of consumers by a cereals supply-chain approach targeting asparagine (AcryRed).

T 18 From Food Matrix to Gut: A Review of Acrylamide Bioaccessibility and Gastrointestinal Fate

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Background: Acrylamide (ACR) is a food process contaminant classified as a "probable carcinogen" (Group 2A) by the International Agency for Research on Cancer [1]. While its formation via the Maillard reaction and its mitigation in industrial settings are well-documented, its behaviour after ingestion remains largely unexplored.
Objective: This study systematically reviewed current evidence regarding the fate of ACR during simulated gastrointestinal digestion (GID) and colonic fermentation across various food matrices.
Methods: A systematic review following PRISMA guidelines was performed to identify studies published between January 2000 and March 2026. Eligible studies included food matrices containing endogenous or spiked ACR, with quantification before and after digestion and/or fermentation.
Results: Data were synthesized from sixteen eligible studies investigating cereal-based products, potato-based foods, coffee, and complex meals. ACR formation is strongly influenced by food composition, processing conditions, and cooking methods. Cereal-based matrices (n = 27), potato-based products (n = 12), and coffee samples (n = 9) were the most frequently investigated. Coffee generally exhibited high ACR bioaccessibility throughout digestion, whereas cereal- and potato-based foods showed matrix-dependent behaviour, with a tendency for ACR levels to increase during the gastric phase and decrease during the intestinal phase [2-4]. Processing interventions such as blanching and air-frying, as well as the incorporation of fibres, protein-rich ingredients, spices, and probiotic formulations, reduced ACR levels or bioaccessibility. Only four studies evaluated colonic fermentation, revealing heterogeneous outcomes.
Conclusions: Gastrointestinal digestion substantially influences the bioaccessibility of ACR. These findings suggest that current exposure assessments based solely on acrylamide concentrations in foods may not accurately reflect actual human exposure, highlighting the need to incorporate bioaccessibility data into dietary risk assessment frameworks

Acknowledgments: Miguel A. Faria acknowledges FCT the researcher contract through CEECINSTLA/00029/2022 DOI 10.54499/CEECINSTLA/00029/2022/CP3029/CT0002. This work received financial support from the PT national funds (FCT/MECI) through the project DOI 10.54499/UID/50006/2025 -Laboratório Associado para a Química Verde - Tecnologias e Processos Limpos, the project neuroNAMix DOI 10.54499/2023.18065.ICDT.

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T 19 Mitigation Strategies for Acrylamide in Cereal-Based Foods: A Systematic Review of Evidence

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Acrylamide formation in cereal-based foods continues to pose a major challenge for food safety, prompting ongoing refinement of mitigation strategies and regulatory guidance. Following the 2019 update of the **Acrylamide Toolbox**, which consolidated state-of-the-art interventions across agricultural, formulation, and processing domains, a systematic evaluation of the evidence base is essential to assess the effectiveness and practical applicability of these measures. To address this need, we conducted a comprehensive systematic review of mitigation strategies in cereal-based foods, structured according to **PRISMA** methodology and implemented within the **CADIMA** review management platform.

A predefined search strategy was applied across major scientific databases, followed by a multi-step screening process performed by a 10-member review team. In total, **1736 titles and abstracts** were screened, **198 full texts** were assessed for eligibility, and **174 studies** were included for data extraction. Extracted data encompassed mitigation interventions aligned with the Toolbox categories, including:

- **Agronomic measures** (varietal selection, fertilization strategies)
- **Recipe and formulation adjustments** (asparaginase application, pH modification, ingredient substitution)
- **Processing interventions** (temperature–time optimization, fermentation, extrusion)
- **Final product strategies** (color control, moisture management)
- **HORECA**

This systematic synthesis will provide the most comprehensive evidence map to date on acrylamide mitigation in cereal-based foods. By combining PRISMA-aligned transparency with CADIMA's structured workflow, the review enhances reproducibility and supports science-based refinement of the Acrylamide Toolbox. The findings highlight both well-established mitigation pathways and areas where further research is needed to inform future regulatory and industry guidance.

Acknowledgments: This research was supported by the COST Action CA21149 Reducing acrylamide exposure of consumers by a cereals supply-chain approach targeting asparagine (AcryRed).

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T 20 How Research Meets Reality: Translating ACRYRED Research into Practical Acrylamide Mitigation for SME Food Production

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Acrylamide mitigation remains a major challenge for cereal-based food manufacturers, particularly those producing foods for infants and young children. For this product category, where the strictest European benchmark levels for acrylamide apply, implementing effective mitigation measures while maintaining product quality presents a particular technological and regulatory challenge. As an SME specialising in infant and young child nutrition, CIBI joined the ACRYRED project not only to gain access to the latest scientific knowledge but also to identify mitigation strategies that could be realistically implemented under industrial production conditions.

Participation in the project significantly improved our understanding of acrylamide formation, its key precursors and the technological factors influencing its occurrence. Through close collaboration with the National Agricultural and Food Centre (NPPC, Slovakia), extensive monitoring of free asparagine and acrylamide in raw materials generated valuable knowledge that enabled the identification of high-risk ingredients and supported evidence-based decisions in raw material selection, recipe development and product formulation. This collaboration supported the development of our mitigation strategy and enabled the practical evaluation of commercially available enzymes and processing aids under pilot-scale conditions. Among the tested solutions, a citric acid-based processing aid showed particularly promising results, achieving a substantial reduction in acrylamide while maintaining the required product quality.

Beyond these technical outcomes, ACRYRED established an effective dialogue between research, industry and regulatory stakeholders. As a food manufacturer operating under current European legislation, we were able to contribute practical experience regarding technological feasibility, implementation challenges and the expected impact of future regulatory requirements. Discussions within the consortium highlighted several issues that remain important for manufacturers, including product categorisation, the practical applicability of mitigation measures across diverse product groups and the need for continuous development of the Acrylamide Toolbox. At the same time, participation in the project ensured early awareness of legislative developments and provided opportunities to discuss practical concerns directly with experts involved in risk assessment and regulatory activities.

Our experience demonstrates that successful acrylamide mitigation requires more than scientific knowledge alone. Sustainable implementation depends on continuous collaboration between researchers, food manufacturers and regulatory stakeholders, ensuring that scientific recommendations are translated into practical, effective and economically feasible solutions. The ACRYRED project confirmed that SMEs are not only beneficiaries of research but also valuable partners in shaping future mitigation strategies and supporting evidence-based regulatory development.

Acknowledgments: The collaboration and presentation was supported with Cost Action 21149 ACRYRED

T 21 ACRYRED Training Schools: A Pan-European Capacity-Building Initiative on Acrylamide Mitigation

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Training Schools constituted one of the key knowledge-transfer and capacity-building activities of the COST Action ACRYRED (CA21149), bringing together early-career researchers, experienced scientists, food industry representatives, and regulatory authorities from across Europe. Organised in Bratislava, Belgrade, Ankara, Tirana, and Plovdiv between 2023 and 2026, the schools addressed the entire cereals supply chain, covering topics ranging from agronomy, plant breeding and genetics to food processing, analytical methods, risk assessment, regulatory frameworks, and industrial implementation of mitigation measures.

Through a combination of lectures, practical demonstrations, laboratory exercises, workshops, site visits, and stakeholder discussions, the Training Schools provided participants with interdisciplinary knowledge and hands-on experience necessary for developing effective strategies to reduce acrylamide formation in cereal-based foods. They also fostered networking, exchange of expertise, and collaboration among researchers from different disciplines and countries, helping to strengthen the scientific community addressing acrylamide-related challenges.

Beyond their educational role, the Training Schools significantly contributed to achieving the broader objectives of ACRYRED by attracting new researchers to the field, promoting harmonisation of methodologies and approaches across Europe, and creating opportunities for direct interaction between scientists, food business operators, and regulatory bodies. The involvement of food industry leaders and competent authorities in the host countries ensured that scientific advances were discussed alongside practical implementation and policy considerations, supporting the translation of research outcomes into effective mitigation strategies and evidence-based decision making.

Overall, the ACRYRED Training School programme established a sustainable platform for knowledge exchange and professional development, strengthening European expertise on acrylamide mitigation and supporting the Action's overarching goal of reducing consumer exposure to acrylamide through an integrated farm-to-fork approach targeting asparagine.

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T 22 Training School on "Approach to the Assessment of Acrylamide Mitigation Measures in Cereal-Based Food Processing"

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The first ACRYRED Training School, *"Approach to the Assessment of Acrylamide Mitigation Measures in Cereal-Based Food Processing"*, was held in Bratislava, Slovakia, on 7-8 September 2023 within COST Action CA21149 ACRYRED. The event aimed to strengthen knowledge and practical skills related to acrylamide mitigation in cereal-based foods and to support harmonisation of methodologies across the ACRYRED network.

A total of **21 trainees from 11 countries** participated in the programme, which was delivered by **14 trainers from academia, research institutes, and industry**. The training combined lectures and laboratory sessions covering dietary acrylamide exposure, European legislation, mitigation strategies included in the Acrylamide Toolbox, analytical methods for acrylamide and asparagine determination, effects of mitigation measures on product quality, and implementation challenges for industry. Practical activities included LC-MS/MS analysis of acrylamide and amino acids, sensory evaluation, texture analysis, and instrumental colour assessment of cereal products.

The Training School provided participants with hands-on experience in evaluating mitigation measures while considering food safety, product quality, nutritional aspects, and technological feasibility. It also promoted networking, interdisciplinary collaboration, and knowledge exchange among early-career researchers and experts. The event established a strong foundation for subsequent ACRYRED training activities and contributed to the Action's objective of reducing consumer exposure to acrylamide through a cereals supply-chain approach targeting asparagine. Proceedings of abstracts and protocols of the Training School are available (ISBN-978-80-89162-86-4).

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T 23 Training School on "Genetics and Agronomy for Low Acrylamide-Forming Potential in Cereals"

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The Training School, "Genetics and Agronomy for Low Acrylamide-Forming Potential in Cereals", was held in Belgrade, Serbia, on 22-24 May 2024, in the frame of the Working Group 2 "Agronomy and Plant Breeding" of the COST Action CA21149 ACRYRED. The Training School was hosted by the Maize Research Institute, Zemun Polje. The event aimed to strengthen knowledge and practical skills on molecular biology, breeding and agronomy targeting free asparagine in cereal genotypes, through interdisciplinary research networking and knowledge exchange. A total of **22 trainees from 10 countries** participated in the programme, which was delivered by **20 lecturers and trainers from academia, research institutes, and industry**. The training combined lectures and laboratory sessions about the application of breeding, agronomy, molecular techniques and chemical methods for low-asparagine cereal genotypes identification and creation. The Training School also promoted networking, interdisciplinary collaboration, and knowledge exchange among early-career researchers and experts. The event established a strong foundation for subsequent ACRYRED training activities and contributed to the Action's objective of reducing consumer exposure to acrylamide through a cereals supply-chain approach targeting asparagine. Proceedings of abstracts and protocols of the Training School are available (ISBN-978-86-80383-17-0).

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T 24 Training School on "Building Skills on the Evaluation of Acrylamide Mitigation Measures in Cereal-based Products with a Risk-Benefit Balance Approach Considering Industry Perspectives and Regulations"

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The COST Action ACRYRED (CA21149) Training School, held at Hacettepe University in Ankara, Türkiye (1-3 October 2024), provided interdisciplinary training on evaluating acrylamide mitigation strategies in cereal-based products using a risk-benefit assessment approach. The event brought together **21 trainees from 11 countries** and was delivered by **11 trainers from 5 countries**, fostering collaboration between academia and industry across Europe.

The program combined expert lectures with practical laboratory training. Topics included acrylamide formation mechanisms, occurrence in cereal-based foods, mitigation approaches, the application of asparaginase, and the influence of baking process parameters on acrylamide generation. Particular attention was given to the effects of mitigation measures on flavour, colour, texture, Maillard reaction products, and regulatory compliance.

Participants gained hands-on experience in the analysis of acrylamide, amino acids, sugars, hydroxymethylfurfural, dicarbonyl compounds, advanced glycation end products, flavour compounds, colour, and sensory attributes. Using whole wheat biscuits as a model product, different mitigation scenarios were evaluated, including recipe reformulation, asparaginase treatment, and changes in biscuit geometry.

Results showed that all mitigation strategies reduced acrylamide levels, although with varying effects on product quality. Reformulation achieved the highest reduction (91%), while asparaginase treatment and biscuit resizing decreased acrylamide by 58% and 62%, respectively. The training strengthened participants' ability to apply integrated risk-benefit principles in developing safer, high-quality cereal-based foods and promoted collaboration within the ACRYRED network.

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T 25 Training School on "Assessing Acrylamide Hazards: Strategies for Risk Mitigation and Legislative Approaches Across Different Countries"

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Training School is organized by Agricultural University of Tirana (AUT), Albanian Institute of Food and Innovation (AIFI) and Food Safety and Veterinary Institute (ISUV) in Albania, on behalf of Cost Action CA21149.This 3-day ACRYRED training is organized by Faculty of Biotechnology and Food with special topics on acrylamide risk assessment and risk strategies as well as on mitigation and legislative approach. **Twelve speakers and 54 participants from 17 countries** have brought to us more scientific and practical knowledge regarding the reducing of the level of acrylamide in some food products considered more hazardous due to the possibility of producing high levels of this chemical contaminant. An open discussions and different opinions about the toxicity of acrylamide, the application of methods for its reduction in food processing and cooking techniques helped all participants to interact and share the knowledge. In addition, one of the debates held was the discussion on benchmark levels and the establishment of maximum residues limits of acrylamide in food. The topic of this training school was broader because it has been focused on discussion for the application of new technologies in the cultivation of agricultural lands using fertilizers containing sulfur as a new method for reducing asparagine levels. Another topic of discussion for reducing acrylamide in food was the application of asparaginase in cereals processing, adding this enzyme as additive. Even the bakery industry is sceptic, the use of asparaginase remains one of more effective way of reducing the amount of acrylamide. Fermentation techniques, heat treatment methods, plant genetic applied methods, cooking and food processing parameters are in way of research and innovation. This training school according to program achieved four specific goals: *Firstly,* the dissemination of knowledge and awareness of food business operators about the risk arising from high levels and exposure to acrylamide in food as well as target toxicity of acrylamide and mitigation strategies. *Secondly,* the dissemination of knowledge regarding new application techniques on food processing as heat treatment methods, use of fermentation methods as well as agricultures technologies on reducing of level e acrylamide in food. *Thirdly,* knowledge was disseminated through sharing of knowledge on the EC legislative approach on setting MRLs for specific groups of foods containing high levels of acrylamide. *Fourthly,* participants had possibility to visit the Institute of Veterinary and Food Safety as National Reference Center for Food Safety in Albania as well as they visited the Cereal Processing Company which is adding asparaginase to reduce the level of asparaginase in wheat flour. Except for these three intensive training days the participants enjoyed their free time carrying out social activities, visiting historical sites and talking which others.

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T 26 Training School on "Integrated Strategies for Acrylamide Reduction: Connecting Agronomy, Genetics and Industry"

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The Training School *"Integrated Strategies for Acrylamide Reduction: Connecting Agronomy, Genetics and Industry"* was held in Plovdiv, Bulgaria, on 15-17 April 2026 within the framework of COST Action CA21149 ACRYRED. The event was hosted by the Agricultural University of Plovdiv and provided an interdisciplinary perspective on acrylamide formation and mitigation, integrating agronomy, genetics, biotechnology, food processing and industry-led approaches.

A total of **40 trainees** participated in the programme (**38 on-site and 2 online**), which was delivered by **12 trainers** (**10 on-site and 2 online**) from universities, research institutes and industry across Europe. The three-day programme combined lectures, discussions, poster sessions, case studies and interactive workshops on acrylamide formation, agricultural practices affecting acrylamide precursors, soil management and fertilisation, cereal breeding, molecular breeding and CRISPR technologies, analytical quality assurance, toxicology, consumer communication and regulatory challenges.

Particular emphasis was placed on integrating agronomic practices, plant breeding and industrial solutions into a coordinated farm-to-fork strategy for reducing acrylamide exposure. Participants explored the potential of low-asparagine cereal varieties, biotechnological approaches, process optimisation and harmonised analytical methods, while discussing challenges related to public awareness, farmer engagement, SME participation and policy development.

The Training School promoted interdisciplinary collaboration, networking and knowledge exchange among researchers, industry stakeholders and early-career scientists. The event contributed directly to the objectives of ACRYRED by supporting the development of science-based and practical strategies for reducing consumer exposure to acrylamide throughout the cereals supply chain.

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T 27 Grant Activities Supporting Collaboration and Capacity Building in ACRYRED

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The grant programme of COST Action CA21149 ACRYRED made a substantial contribution to strengthening scientific collaboration, researcher mobility, knowledge exchange, and capacity building across Europe. During the Action, **50 grants** with a total value of **€89,885.92** were awarded through **Short-Term Scientific Missions (STSMs), Dissemination Conference Grants, Virtual Mobility Grants, Young Researcher and Innovator (YRI) Conference Grants, and Inclusiveness Target Country (ITC) Conference Grants**.

The programme supported **11 STSMs, 6 Virtual Mobility Grants, and 33 conference grants** (among them **15 Dissemination Conference Grants and 12 YRI Conference Grants**), fostering knowledge exchange, international networking, research dissemination, and career development. Particular emphasis was placed on supporting early-career scientists and researchers from Inclusiveness Target Countries, with **30 grants awarded to Young Researchers and Innovators and 30 grants to participants from ITCs**. Researchers from **17 countries** benefited from the programme, with the highest number of grants awarded to participants from **Italy (8), Poland (6), and Türkiye (5)**.

ACRYRED grants supported scientific activities in **18 host countries**, with the most frequent destinations being **Slovakia (11 grants), Germany (5 grants), France (4 grants), and Croatia (4 grants)**, demonstrating the broad geographical reach of the Action and its contribution to strengthening research collaboration across Europe and beyond.

Through these activities, the grant programme strengthened international networking, facilitated the exchange of expertise, and created opportunities for the development of new collaborative research initiatives addressing acrylamide mitigation in foods. The grant activities therefore made a significant contribution to achieving the objectives of the ACRYRED COST Action and to ensuring the long-term sustainability of its research network.

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T 28 From STSM to Scientific Collaboration: Green Lentil Fortification of Wheat Bread and Acrylamide Formation as an Outcome of Knowledge Exchange

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The Short-Term Scientific Mission (STSM) programme within the ACRYRED COST Action CA21149 provides valuable opportunities for scientific collaboration, knowledge exchange, and networking among researchers from different institutions and countries. This contribution presents the outcomes of an STSM collaboration focused on the application of green lentils in wheat bread production and their impact on product quality and safety. The collaboration enabled the exchange of expertise in cereal technology, food safety assessment, fermentation processes, and analytical methodologies. Through joint experimental work and scientific discussions, researchers investigated the effects of untreated, milled, and *Lactiplantibacillus plantarum*-fermented green lentils on selected quality and safety characteristics of wheat bread, including overall acceptability, texture, technological parameters, volatile compound profile, and acrylamide formation. The study demonstrated that breads enriched with green lentils maintained consumer acceptability comparable to conventional wheat bread at several inclusion levels. However, lentil processing methods significantly affected bread characteristics and acrylamide concentration. Milled lentils resulted in higher acrylamide levels than non-milled lentils, while fermentation combined with milling further promoted acrylamide formation, likely due to increased availability of free amino acids. Significant relationships were observed between acrylamide concentration and bread acidity, moisture content, crust color, and volatile compound formation. The lowest acrylamide concentrations were achieved in breads enriched with 5–15% fermented, non-milled green lentils. Beyond the scientific findings, the STSM facilitated the development of new research skills, strengthened international cooperation, and established a foundation for future collaborative activities in the field of food quality and safety. The experience highlights the importance of researcher mobility programmes in generating innovative research outcomes while fostering long-term scientific partnerships within the ACRYRED network.

Acknowledgments: This work is based upon the work from COST Action CA21149 ACRYRED "Reducing acrylamide exposure of consumers by a cereals supply-chain approach targeting asparagine" Short-Term Scientific Mission „The influence of different non-bread ingredients on the formation of acrylamide in bread" held on 17/06/2024 – 01/07/2024 in Lithuanian University of Health Sciences (Kaunas, Lithuania).

T 29 The investigation of shortbread of different formulations in the course of an ACRYRED STSM stay @ Graz University of Technology

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Short term scientific missions (STSM) are an important component of COST Actions, supporting and facilitating collaborations between research groups from different countries and promoting long-term scientific cooperations.
During the ACRYRED COST Action, Magdalena Surma, Professor at the University of Krakow, applied for an STSM to be carried out at the Institute of Analytical Chemistry and Food Chemistry at Graz University of Technology. This STSM took place in March 2024, during which Magdalena spent four weeks conducting research at our institute. Magdalena's expertise lies in the analysis of process and enviromental contaminants as well as of bioactive compounds in food matrices, whereas my personal research focuses on flavour chemistry and sensory science. Based on these complementary areas of expertise, we designed a joint research project investigating shortbread cookies prepared with different formulations, with particular emphasis on the use of fat substitutes. The cookies were produced in Magdalena's laboratory under standardised conditions using well-defined formulations. We approached this investigation from two complementary perspectives: (i) the analysis of process contaminants (e.g. acrylamide, 5-HMF, 2- & 3-MCDP and glycidol ester (GE) in the Krakow laboratory and (ii) aroma compounds and sensory evaluation in the Graz laboratory. Combining the complementary expertise of both research groups enabled us to gain comprehensive insights into the impact of fat substitutes on the chemical and sensory properties of shortbread cookies. The results of this collaborative study are currently being prepared for publication in the journal *Food Chemistry*.
In addition to the scientific work accomplished during the STSM, Magdalena an I had the opportunity to establish a scientific cooperation which would not have been possible without this support. Our early-career researcher in Graz were actively involved in the project and supported Magdalena in carrying out the experimental work. For them, it was a great experience as young scientists to work closely with an internationally recognised researcher and to introduce her to the analytical and sensory techniques applied at our institute. Furthermore, Magdalena held two talks, one at our institute and another for a broader audience within the faculty, where she introduced her research activities.
Beyond the scientific outcomes, the STSM gave us the opportunity to get to know Magdalena on a personal level. Numerous conversations during coffee breaks, and also on our trip to the Zotter Chocolate Factory and the visit of the Riegersburg Castle extended beyond science and allowed to make friends between colleagues from Austria and Poland.

Acknowledgments: The author is grateful to the COST Action CA21149 for providing the financial support for Magda's stay at our institute. I would also like to acknowledge Magda Surma for the good cooperation, Anna Sadowska-Rociek, University of Agriculture in Krakow for her cooperation in the project and to Sabrina Stranig and Jana Reiter from Graz University of Technology for their assistance in the laboratory.

T 30 How fat substitutes in shortbread influence the formation of flavour and process contaminants

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During a four-week Short-Term Scientific Mission in March 2024, under the supervision of Barbara Siegmund, I investigated the effect of selected fat substitutes (Plantago psyllium, barley fibre Vitacell BG 300, and avocado puree) on the formation of acrylamide, other process contaminants, and flavour compounds in various shortbread formulations.

The study was based on the assumption that recipe composition influences both desirable flavour development and the formation of process contaminants during the baking process. Shortbread samples containing different fat substitutes were prepared under standardized conditions. The products were analysed for acrylamide (AA), 5-hydroxymethylfurfural (5-HMF), 2-chloropropane-1,3-diol (2-MCPD), 3-monochloropropane-1,2-diol (3-MCPD), glycidyl esters (GE), and flavour compounds. Sensory evaluation was performed by trained panellists using both 9-point hedonic tests to assess consumer acceptance and Open-Ended Questioning (OEQ) to characterize specific sensory attributes. Sensory evaluation and flavour compounds analysis of shortbread were carried out in the Sensory laboratory of the Institute of Analytical Chemistry and Food Chemistry at the Graz University of Technology. Other analyses were carried out at the Department of Food Technology at the University of Agriculture in Krakow.

With this study, we gained a comprehensive data set regarding flavour compounds and sensory properties related process contaminants of this specific bakery goods. The results show that the addition of Psyllium as well as higher amounts of barley fibre led to a reduced AA formation, while the other modifications of the formulation did not. Analysis of the volatile compounds shows, that the addition of avocado has the highest influence on the flavour formation, while the addition of Psyllium and barley fibre have minor impact. Multivariate statistical analysis (WIP) including the whole data set provides deep insight in how fat substitutes in shortbread formulations may impact acrylamide in relation to flavour formation with additional information on 2- and 3-MCPD, HMF and GE in the investigated shortbread formulations.

The outcomes of this research contribute to the objectives of the Action by improving understanding of strategies to reduce acrylamide in cereal-based foods while maintaining desirable sensory quality. The project strengthened scientific collaboration between the University of Agriculture in Krakow and Graz University of Technology, promoted knowledge exchange across disciplines, and supported future joint research. During the mission, I also acquired practical expertise in solid-phase microextraction (SPME) for the analysis of volatile compounds in food through collaboration with Sabrina Stranig.

Acknowledgments: The research was conducted within the framework of a Short Term Scientific Mission (STSM) Grant, which was supported by COST Action: CA21149.

T 31 Effect of rice flour extrusion on α-dicarbonyl compounds, protein glycation products, and the formation of acrylamide and 5- hydroxymethylfurfural in bread crust-like system

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The STSM aimed to investigate the effects of the extrusion process of rice flour, an established method for enhancing the quality of gluten-free bread, on the formation of Maillard reaction products (MRPs) in gluten-free model matrices. Extrusion parameters, including temperature (80°C and 120°C), feed moisture content (15% and 30%), and particle size (<132 µm and 132–200 µm) were systematically varied. The study focused on quantifying key Maillard reaction products, such as hydroxymethylfurfural (HMF), acrylamide, and α-dicarbonyl compounds (3-deoxyglucosone (3-DG), glucosone (G), glyoxal (GO), methylglyoxal (MGO), and diacetyl (DA)), as well as advanced glycation end-products, including N-ε-fructosyllysine, N-ε-carboxymethyllysine (CML), and N-ε-carboxyethyllysine (CEL). Additionally, the levels of reaction precursors, including sugars and free amino acids, were assessed in the flours.
A crust-like model system was developed to simulate the baking process. In this model, 10% of commercially available rice flour was replaced with extruded rice flour produced under varying extrusion parameters, thereby mimicking realistic baking conditions. Despite differences in the water-holding capacity of the flours, the same amount of sucrose–water solution was added to all samples to ensure consistency. The formulation can be considered comparable to that used in gluten-free bread model systems.
The findings from this research, conducted during the STSM, are expected to contribute to a scientific paper that will enhance the understanding of the parameters critical for conducting risk-benefit analyses of Maillard reaction products. This work directly supports the objective of enabling discussions on the balance between risks and benefits associated with MRPs, particularly in the context of cereal-based foods, and aligns with Task 5.1, which aims to compile a comprehensive overview of relevant research on MRPs and their risk-benefit balance.
In addition to advancing the young researcher's scientific development, this STSM facilitated the establishment of a long-term collaboration with a leading research center in this field. Ongoing conferences for planning activities and discussing results will sustain this partnership. Future collaboration will focus on planning further experiments, which could be conducted during a subsequent visit or an extended research stay.

Keywords: Rice flour, extrusion, Maillard reaction, advanced glycation end products, acrylamide, 5-hydroxymethylfurfural

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T 32 Sulphur Fertilization Effects on Acrylamide Precursor Dynamics and Grain Quality in Autochthonous Wheat Varieties from Bosnia and Herzegovina

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Within the framework of the COST Action ACRYRED (CA22144), this activity was carried out to support collaborative research and methodological harmonisation on the assessment of acrylamide precursors in wheat grain. A Short-Term Scientific Mission (STSM) was conducted at the National Agricultural and Food Centre in Bratislava from 24 June 2024 to 14 July 2024, with the aim of jointly investigating the effects of sulphur fertilization on wheat grain quality and acrylamide precursor compounds, while improving analytical comparability between partner laboratories. The STSM involved joint experimental work and training in analytical procedures for wheat grain samples originating from field experiments in Bosnia and Herzegovina. Two local winter wheat varieties from Bosnia and Herzegovina (*Omerson* and *Falado*) were included in the study. Standardised protocols were applied for the determination of free asparagine (LC–MS/MS) and reducing sugars (HPLC-RID), together with grain quality assessment using NIR spectroscopy. The activity also included alignment and optimisation of extraction and analytical workflows across institutions. The results obtained during the STSM confirmed clear effects of sulphur fertilization on acrylamide precursor dynamics in a genotype-dependent manner. Free asparagine content was reduced by up to 24% in *Omerson* and by 9% in *Falado* under the highest sulphur treatment, indicating a stronger response in *Omerson*. Reducing sugars showed cultivar-dependent responses, with increases in glucose and fructose observed in *Omerson* (up to +14% and +13%, respectively), while *Falado* showed decreases in both sugars under increasing sulphur supply. Maltose remained largely stable across treatments. Grain composition was not significantly affected by sulphur fertilization, while technological quality traits showed cultivar-dependent variation. The STSM resulted in a harmonised analytical workflow and a validated dataset suitable for integration into ongoing ACRYRED activities, improving data comparability across partner laboratories. Beyond scientific outputs, the STSM significantly contributed to capacity building, knowledge transfer, and strengthening of interdisciplinary collaboration between agronomy and food chemistry partners. The generated dataset and harmonised methodologies will support further joint data analysis and comparative studies within the ACRYRED network. Planned follow-up activities include joint interpretation of results, development of future collaborative research proposals and researcher exchange activities, with results to be further developed into a peer-reviewed publication.

Acknowledgements: This work was carried out within the COST Action ACRYRED (CA22144) through a Short-Term Scientific Mission (STSM). The author acknowledges the National Agricultural and Food Centre (Bratislava, Slovakia) for hosting the research stay and providing laboratory facilities, as well as the University of Banja Luka for supporting field and laboratory activities.

T 33 Impact of Formula and Processing Technology on Acrylamide Formation and Amino Acid Composition in Bread

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Thermal processing and long-term storage of food initiate complex chemical reactions between carbonyl groups of reducing sugars and amino groups of amino acids, peptides, and proteins. This set of reactions, known as the Maillard reaction, is responsible for desirable flavor, aroma, and color formation, but also for the generation of potentially harmful compounds such as acrylamide. Free asparagine is recognized as a key precursor in acrylamide formation, and its concentration in cereal raw materials may significantly influence acrylamide levels in processed foods.
The present study aimed to evaluate the content of amino acids and acrylamide in model bakery products obtained from two oat varieties (spring and winter) and to determine the effect of baking parameters on acrylamide formation. Breads were prepared under two baking conditions (200°C/90 min and 180°C/120 min). The content of amino acids (Asn, Asp, Gln, Glu) and acrylamide was determined using previously developed HPLC and LC-MS methods.
Spring oat grain contained approximately twice the level of the analyzed amino acids compared to winter oat; however, this difference was not reflected in the final bread products. Baking parameters significantly affected acrylamide formation. Lower temperature combined with extended baking time reduced acrylamide levels, whereas increasing temperature and modifying the baking conditions resulted in a twofold increase in acrylamide content in breads from both oat varieties. No significant varietal effect on the analyzed compounds was observed.
The results confirm that baking time and temperature are critical determinants of acrylamide formation in fresh bread, while further characterization of oat varieties may support the development of improved cereal-based products.

Acknowledgments: This contribution was supported by STSM of Dr. M. Starowicz in the NPPC (Slovakia) under supervision of Dr. Z. Ciesarova and Dr. K. Kukurova.

T 34 Thermal Processing Effects on Acrylamide Formation in Dry Peas (*Pisum sativum* L.)

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The safety aspects of heat treatments of dry peas have been largely overlooked in the literature, despite their application in improving techno-functional and sensory properties, as well as reducing antinutrient content. Raw pea seeds of cultivars “Dunav” (D) and “Tamiš” (T) were subjected to different thermal treatments, including: conventional cooking (D2 and T2), roasting in a microwave oven (D3 and T3), autoclaving (D4 and T4), oven roasting at 120°C (D5 and T5), oven roasting at 160°C (D6 and T6) and air frying at 180°C (D7 and T7). Untreated samples were used as a control (D1 and T1). Treatments were selected based on previous studies [1–4]. Acrylamide content was determined using the methods of Ciesarová et al. [5] and Kukurová et al. [6], with modifications to the chromatographic system.

Most samples contained acrylamide below the quantification limit (15 µg/kg). The highest levels were detected in air-fried samples D7 and T7 (1388 and 1733 µg/kg, respectively), followed by samples oven-roasted at 160°C (D6: 54 µg/kg; T6: 123 µg/kg). Interestingly, cultivar “Tamiš” also showed quantifiable acrylamide after microwave roasting and autoclaving. Cooking and oven roasting at 120°C produced no detectable acrylamide in either cultivar. This STSM established acrylamide levels in dry peas subjected to different heat treatments, supporting ACRYRED’s objective of understanding and mitigating acrylamide formation in grain-based foods, especially the objective of WG3 – Food Chemistry & Processing to deepen the understanding of how raw material profiles influence the quality of final products.

Acknowledgments: Ministry of Education, Science and Technological Development of the Republic of Serbia, (grant 451-03-33/2026-03/200222) and Slovak Research and Development Agency (grant APVV 23-0169). This work was completed during the short-term scientific mission (STSM) of Dr. Miona Belović at the National Agricultural and Food Centre, Food Research Institute, Bratislava, Slovakia carried out under the COST Action ACRYRED (CA21149).

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T 35 ACRYRED Community Position on the Use of Benchmark and Maximum Levels for Acrylamide Risk Management

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Acrylamide is regarded as one of the most important process contaminants formed during thermal processing of cereal-based and other carbohydrate-rich foods. Since the implementation of Commission Regulation (EU) 2017/2158[2], benchmark levels (BMLs) and mitigation measures have contributed to a significant reduction of acrylamide occurrence in numerous food categories. However, the European Commission is currently considering further revision of benchmark levels and the introduction of maximum levels (MLs) for selected foods. In response, members of COST Action CA21149 ACRYRED prepared a consensus position paper addressing the scientific and practical implications of different regulatory approaches to acrylamide management.

The ACRYRED community reviewed current knowledge on acrylamide toxicology, exposure assessment and mitigation strategies, together with regulatory concepts used for contaminant control. Particular attention was given to the distinction between benchmark levels as mitigation targets and maximum levels as legally enforceable market limits. The review highlighted that acrylamide exposure originates from a broad range of foods and that it is logical for background exposure to be managed primarily through the benchmark-level approach. While maximum levels may offer advantages for enforcement and may be justified for foods contributing disproportionately to dietary exposure or intended for sensitive population groups, their application should be supported by scientific evidence demonstrating added value for consumer protection.

The position paper emphasizes that regulatory measures should maintain a clear connection between risk reduction objectives and control actions. The ACRYRED community advocates the adoption of an "ALARA + Safety-based" approach, combining achievable mitigation targets with periodic evaluation of their effectiveness in reducing consumer exposure. The document also identifies the need for improved food categorization, greater transparency in limit-setting procedures, enhanced communication of scientific uncertainties, and strengthened collaboration between food business operators, enforcement authorities and researchers.

The resulting consensus document represents a multidisciplinary contribution from plant scientists, food technologists, analytical chemists, toxicologists, industry representatives and regulators participating in ACRYRED. It provides scientific input to ongoing European discussions concerning the future framework for acrylamide risk management and supports evidence-based decision-making aimed at protecting consumer health while avoiding disproportionate impacts on food production and market availability.

Acknowledgments: This publication is based upon work from COST Action CA21149 ACRYRED, supported by COST (European Cooperation in Science and Technology).

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[2] Commission Regulation (EU) 2017/2158 establishing mitigation measures and benchmark levels for the reduction of the presence of acrylamide in food.

T 36 A five-year farm-to-fork strategy for acrylamide reduction: priorities for ACRYRED Work Group 4

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Acrylamide remains a significant food-chain challenge because its formation is influenced by raw-material composition, agronomy, storage, processing and consumer preparation. This Work Group 4 contribution converts the available evidence into a five-year, farm-to-fork strategy for reducing acrylamide exposure in the European food chain. The strategy combines upstream control of free asparagine and reducing sugars with product-specific processing interventions, harmonised monitoring, regulatory development and consumer guidance. The proposed agronomic package prioritises adequate sulphur, restrained nitrogen, disease and stress management, locally validated low-asparagine cultivars and rapid screening of high-risk raw materials. Processing measures include reduced thermal load, shorter exposure, blanching, fermentation, vacuum or air-based technologies and asparaginase where appropriate for conventional products.
A distinct organic-food pathway is proposed because organic products should not depend on asparaginase. This pathway therefore emphasises low-precursor ingredients, balanced agronomy, storage control, soaking, washing, blanching, fermentation, moisture and pH management, lower-temperature processing, permitted natural formulations and finished-product verification.
The implementation plan is staged:
Years 1–2 establish harmonised baselines, methods, datasets and guidance;
Years 2–3 expand field screening, procurement standards and commercial validation;
Years 3–4 review evidence for lower benchmarks or maximum levels and evaluate rapid tests; and
Years 4–5 introduce tighter product-specific measures where justified and evaluate exposure, compliance, quality and unintended effects. The evidence supports free asparagine as a measurable supply-chain target, but does not yet justify one universal EU maximum for wheat grain because genotype, environment, agronomy and processing create substantial variation. In the near term, adaptive reference bands, disclosure, procurement incentives and harmonised monitoring should complement product-specific acrylamide controls. The strategy provides WG4 with a scientifically credible and commercially feasible framework for coordinated action across farming, manufacture, regulation, retail, catering and households.

Acknowledgments: This work is based upon activities undertaken within ACRYRED Work Group 4.

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ABSTRACTS OF POSTERS

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P 01 Free asparagine distribution in wheat and rye milling fractions: Evidence from fertilization trials

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Understanding how free asparagine is distributed among cereal milling fractions is important for evaluating agronomic strategies aimed at acrylamide mitigation. However, the influence of fertilization practices on this distribution has not yet been systematically investigated. A total of 56 winter wheat (Triticum aestivum L.) and 34 winter rye (Secale cereale L.) grain samples obtained from field fertilization trials with different nitrogen (N) and nitrogen–sulphur (N+S) regimes were selected for milling. Fractionation yielded 360 milling fractions, which, together with the corresponding whole grain samples, were analysed for free asparagine content.
A highly uneven distribution of free asparagine was observed among milling fractions. Bran fractions represented the major reservoir of free asparagine, accounting for approximately 70% of the total content in wheat and up to 90% in rye. Evaluation of individual milling fractions revealed fertilization effects that were less evident when only whole grain was considered, demonstrating that grain-level measurements may not fully reflect changes occurring within flour and bran fractions. The two-year dataset further enabled fertilization effects to be evaluated in the context of year-to-year variability and differing environmental conditions. By linking agronomic management with technological fractionation, this study provides a systematic evaluation of how fertilization effects observed at the whole grain level are reflected in individual milling fractions.
These results of presented pilot study provide new insight into free asparagine distribution in cereal grain and highlight the importance of considering individual milling fractions when assessing agronomic approaches for mitigation of acrylamide in thermally processed cereal-derived products.

Acknowledgments: This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic within the INTER-EXCELLENCE II programme, subprogramme INTER-COST, project No. LUC23140 (“Safe and tasty thermally processed foods prepared from low-asparagine cereals”). The work also used data/tools/services/facilities provided by the METROFOOD-CZ Research Infrastructure (https://metrofood.cz), supported by the Ministry of Education, Youth and Sports of the Czech Republic (Project No. LM2023064). This work was also supported from the grant of Specific university research – grant No A1_FPBT_2026_001.

P 02 Determination of Some Properties of Halva Made from Kavilca and Wheat Flour

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By the mounting global significance of concepts such as food safety, biodiversity and sustainability, there is an imperative for a re-evaluation of traditional agricultural systems and ancestral seeds in modern food production processes. Kavılca wheat, cultivated in the Ardahan region, is distinguished by its elevated nutritional value, resilience, and cultural significance. Kavılca, an ancient wheat variety cultivated in Türkiye's Anatolian region for thousands of years, is an important source of dietary fiber, contains relatively low gluten levels, and is rich in essential nutrients such as B vitamins, zinc, and magnesium. In the course of the research project, a comparison was made of halvas produced with Kavılca and white flour. The comparison was made in terms of physical properties (baking loss, colour), structural properties (hardness, elasticity), chemical properties (sugar, HMF, acrylamide content) and sensory properties (taste, odor, general acceptance). In this study, the physical, functional and nutritional properties of halvas were significantly improved by using whole wheat Kavılca flour. The browning index were determined to be 59.13±2.42 and 65.73±2.96 for made of halvas produced with Kavılca (KH) and for made of halvas produced with White flour (WH), respectively. The hardness values of the products recorded as 3.62±0.52 and 5.52±0.89 for KH and WH, respectively. The acrylamide content was determined to be 90.20±5.36 and 190.85±10.96 (µg/kg) for WH and KH, respectively. The sensory characteristics of the production made with Kavılca flour founded to be highly regarded by experts, particularly in relation to its aroma and overall acceptability. In conclusion, the use of traditional whole wheat flour-enriched halva, especially when incorporated into grain-based products, has potential to yield products offering enhanced health benefits.

Fig.1. Halva Samples (H-158: wheat flour halva; H-214: kavilca flour halva)

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P 03 Role of glutathione and cycteine in acrylamide metabolism during in vitro and in vivo digestion

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Acrylamide, defined as a probable human carcinogen, forms during the thermal treatment of certain foods via Maillard reaction. The reactivity of acrylamide toward amino and thiol groups and leading to the formation of Micheal adducts provides an efficient strategy for reducing its toxic effects. To proof that, this study aims to investigate how selected thiol compounds (glutathione and cysteine) effects the fate of acrylamide both *in vitro* simulated digestion and *in vivo* studies in a mouse model.
Two experimental procedures were applied to evaluate the effects of glutathione (GSH) and cysteine: (i) digesting reformulated chips containing 1% GSH or 0.5% cysteine, and (ii) co-digesting control chips with 1% GSH or 0.5% cysteine solutions to monitor the fate of acrylamide *in vitro*. For *in vivo* studies, six-week-old male C57BL/6N mice were fed a diet with or without reformulated potato chips for 7 days to monitor acrylamide metabolites in urine samples.
The initial acrylamide concentration of control snacks was 1749.6±0.1 µg/kg. Addition of 1.0% GSH or 0.5% cysteine to the formula resulted in 84.7% and 87.0% decrease in acrylamide content during baking, respectively. However, neither GSH nor cysteine exhibited further decreasing effect during the digestion of reformulated chips, likely due to oxidation of GSH and cysteine into their inactive forms as GSSG and cystine, respectively. On the other hand, co-digestion model demonstrated that further mitigation of acrylamide during digestion. Even after the oral phase, acrylamide concentration decreased by 19% with total reduction reaching to 67% (with 0.5% cysteine) and 70% (with 1% GSH) by the end of the intestinal phase due to the presence of their free form. GSH-acrylamide and two acrylamide-cysteine adducts confirmed in co-digested samples via high resolution mass spectrometry. Major indicative metabolites (AAMA, GAMA, and glycidamide) were monitored in urine samples collected from mice to assess detoxification efficiency *in vivo*. Reformulation with GSH reduced GAMA and increased AAMA levels, while cysteine-containing chips reduced both. This might be due to GSH preventing the transformation of acrylamide into glycidamide. These findings indicated that GSH-containing chips enhance acrylamide detoxification more efficiently than cysteine-containing chips *in vivo*.
This study proved that thiol compounds are effective in reducing acrylamide exposure following the consumption of potato chips.

Acknowledgments: This work was supported by the Scientific and Technological Research Council of Türkiye under grant number 122N952 and by the Scientific Research Projects Coordination Unit of Hacettepe University under grant number FHD-2024-21547 and the Mid-career Researcher Program through the National Research Foundation of Korea (NRF) under grant number RS-2023-NR076822 and by the Bilateral Exchange Program through the National Research Foundation of Korea (NRF) under grant number RS-2023-NR066871.

P 04 Protective Effects of Lutein Against Acrylamide-Induced Ferroptosis in Human Vascular Endothelial Cells

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Acrylamide, a widespread environmental contaminant derived from food processing and industrial sources, is known to induce vascular endothelial damage through the induction of oxidative stress. Ferroptosis, an iron-dependent form of regulated cell death characterized by lipid peroxidation, has recently been proposed as a potential underlying mechanism of acrylamide-induced endothelial dysfunction. Lutein, a carotenoid known for its potent antioxidant and membrane-stabilizing properties, has been shown to exert protective effects against oxidative damage in various cell types. In this study, we aimed to investigate whether acrylamide induces ferroptosis-mediated endothelial dysfunction in human umbilical vein endothelial cells (HUVECs), and to evaluate the potential protective effect of lutein against this process.

HUVECs were pre-treated with lutein for 24 hours prior to acrylamide exposure, followed by 24 hours of acrylamide treatment. Rescue experiments with the ferroptosis inhibitor ferrostatin-1 were performed to confirm the ferroptosis-specific nature of the observed effects. Cell viability was assessed by MTT assay, and ferroptotic cell death was visualized by fluorescence microscopy using FerroOrange staining. Expression levels of GPX4 and SLC7A11, key regulators of ferroptosis, were analyzed by qPCR.

Cell viability assays demonstrated that acrylamide treatment (5 mM, 24 h) markedly reduced HUVEC viability to 39.14% relative to control (100%). Lutein alone (10 µM) did not adversely affect cell viability (88.05%), confirming its tolerability. Co-treatment with lutein significantly attenuated acrylamide-induced viability loss (63.77%), while co-treatment with the ferroptosis inhibitor ferrostatin-1 also markedly restored viability (72.83%), supporting the involvement of ferroptosis in acrylamide-induced endothelial injury. Interestingly, combined treatment with lutein and ferrostatin-1 in the presence of acrylamide resulted in a viability of 60.49%, lower than either agent alone, suggesting a possible interaction between the two protective mechanisms that warrants further investigation. FerroOrange staining and GPX4/SLC7A11 expression analyses are ongoing to further characterize the ferroptosis-dependent mechanism and the protective action of lutein.

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P 05 Occurrence, Influence of Brewing Methods, and Risk Assessment of Dietary Exposure to Acrylamide in Coffee Beverages in Brazil

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Acrylamide is a process contaminant formed during the thermal treatment of foods containing free amino acids and reducing sugars, and it is classified as a probable human carcinogen. Coffee constitutes one of the main sources of dietary exposure to this compound, and the concentrations transferred to the beverage can vary significantly depending on the brewing method. The objective of this study was to evaluate the occurrence of acrylamide in coffee beverages, investigate the impact of different brewing methods on the contaminant concentrations, and determine the dietary exposure and risk for the Brazilian population. A total of 36 ready-to-consume beverage samples (12 espressos, 12 French presses, and 12 filtered coffees) were collected from four commercial establishments in the city of Campinas, Sao Paulo, over three consecutive weeks. The extraction procedure involved 10 mL beverage aliquots fortified with the internal standard acrylamide-d3, subjected to protein precipitation clarification using Carrez I and II solutions, followed by degreasing through liquid-liquid extraction with dichloromethane. Analytical determination was conducted using ultra-high performance liquid chromatography-tandem mass spectrometry (UHPLC-MS/MS) operating in positive electrospray ionization and selected reaction monitoring (SRM) mode. The results revealed statistically significant variations ($p < 0.05$) among the commercial modalities evaluated. Espresso presented the highest mean concentration (41.92 ± 16.64 µg/L), followed by filtered coffee (27.92 ± 18.62 µg/L) and French press (19.92 ± 8.26 µg/L). The estimated daily intake (EDI) was calculated deterministically by multiplying the mean concentrations by the daily coffee consumption and dividing by the standard body weight of 60 kg for the adult population. The average daily consumption considered for the Brazilian population was 163.0 g based on the Consumer Expenditure Survey (POF). The EDI values obtained for the average general population were 0.113 µg/kg bw/day for espresso, 0.054 for French press, and 0.075 for filtered coffee. Risk characterization was performed using the Margin of Exposure (MOE) approach, dividing the toxicological benchmark dose lower confidence limit (BMDL10) by the corresponding EDI, following JECFA and EFSA recommendations. The calculated MOE values for the average general population were 1593 for espresso, 3333 for French press, and 2426 for filtered coffee. All values were considerably below the international safety threshold of 10000 recommended for genotoxic and carcinogenic substances. In conclusion, the brewing method directly influences human exposure to acrylamide through coffee, and the obtained margins of exposure indicate a potential public health concern, highlighting the urgency of continuous monitoring of this chemical contaminant in the diet.

Keywords: Acrylamide, Coffee beverages, UHPLC-MS/MS, Margin of exposure.

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P 06 Effect of Nitrogen and Sulfur Fertilization Timing on Free Asparagine Content in Winter Rye Grain

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Free asparagine (Asn) is the primary precursor of acrylamide formation during the thermal processing of cereal-based products [1]. Compared with other cereal species, rye (Secale cereale L.) has consistently higher concentrations of this amino acid; however, the mechanisms and factors governing its accumulation remain insufficiently understood [2]. This study aimed to evaluate the effects of nitrogen (N) and sulfur (S) fertilization rates and application timing on free Asn content in winter rye grain. A small-plot field experiment was conducted at the experimental station of the Czech University of Life Sciences Prague in Uhříněves during the 2024 and 2025 growing seasons. Two cultivars (the population cultivar Inspektor and the hybrid cultivar SU Performer) were evaluated under seven fertilization treatments comprising N application rates of 60 and 120 kg N ha^{-1} with different application timings (early spring regenerative, production, and split applications), including four treatments supplemented with sulfur (40 kg S ha^{-1}) applied at the corresponding growth stages. The concentrations of free amino acids were determined using ultra-high-performance liquid chromatography coupled with high-resolution mass spectrometry (UHPLC-HRMS) [3]. The free Asn concentrations ranged from 740 to 1,086 mg kg^{-1}, with a mean value of 891 ± 87 mg kg^{-1}. The highest Asn content was recorded at the N rate of 120 kg ha^{-1} (952 mg kg^{-1}), representing an 11% increase compared to the 60 kg N ha^{-1} treatments (861 mg kg^{-1}). The unfertilized control contained 810 mg kg^{-1} Asn. At the commonly applied N rate of 60 kg ha^{-1}, both the timing of N application and S supplementation significantly influenced Asn accumulation in the present study. The lowest Asn concentration (847 mg kg^{-1}) was achieved when the entire 60 kg N ha^{-1} dose was applied during early spring regenerative fertilization together with 40 kg S ha^{-1}. The same N rate applied without sulfur resulted in a higher Asn content (888 mg kg^{-1}), whereas sulfur supplementation associated with the production N application resulted in intermediate Asn concentrations (867 mg kg^{-1}). The crop year also had a significant effect, with grain harvested in 2024 containing, on average, 10% more Asn than that harvested in 2025. After accounting for the effects of crop year and the smaller effect of cultivar, the timing of early spring N application in combination with sulfur fertilization emerged as the most important agronomic factor affecting free Asn accumulation in winter rye grains.

Acknowledgments: This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic within the INTER-EXCELLENCE II programme, subprogramme INTER-COST, project No. LUC23140 ("Safe and tasty thermally processed foods prepared from low-asparagine cereals").

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P 07 Synthesis of acrylamide-free Maillard reaction flavours using mechanochemistry in model systems

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In the food industry, particularly in bakery products and snacks, heat treatments ensure microbial safety as well as the formation of volatile compounds characteristic baked and roasted flavor notes, such as Strecker aldehydes and pyrazines, through the Maillard reaction. While flavor is one of the most critical factor determining consumer preference, traditional high-temperature applications lead to significant energy consumption and the formation of heat treatment contaminants such as acrylamide, which pose health risks. Therefore, there is a need for innovative and sustainable alternative food processing methods that eliminate the risk of acrylamide without compromising sensory quality and flavor profile. The aim of this study is to obtain the desired aroma compounds by triggering the Maillard reaction using a mechanochemical approach instead of traditional heating methods, while limiting acrylamide formation. In the line of the study, model systems were created containing asparagine with sucrose, fructose, glucose, and 2-phenylglyoxal (1:1 molar ratio), and 2-phenylglyoxal with leucine, phenylalanine, alanine, glycine, and a leucine-phenylglyoxal mix (1:1 molar ratio). Samples were prepared through ball milling at ambient temperature. All mechanochemical reactions were conducted in a 2 mL stainless-steel grinding jars with two steel balls. The jars were seated in ball-mill that performs radial oscillations in a horizontal position at a frequency of 30 Hz for 30 min. Samples collected after milling were stored at -40 °C for further analysis. Acrylamide in asparagine-containing samples was determined by LC–MS after dilution of 30 mg sample with 0.5 mL water, that contain 10 ppb d3 acrylamide as an internal standard and 10 mM formic acid. A calibration curve for quantification of acrylamide was built at concentrations of 0.5-10 ng/mL. Volatile components in leucine, phenylalanine, alanine, and glycine-containing samples was analyzed by SPME-GC-MS. As a result, mechanochemical treatment in a ball-mill promoted Strecker degradation during the Maillard reaction in mixtures of leucine, phenylalanine, alanine, or glycine with α-dicarbonyl compounds, leading to the formation of amino acid-specific Strecker aldehydes. Specifically, 3 methylbutanal, phenylacetaldehyde, and acetaldehyde were identified as the Strecker degradation products of leucine, phenylalanine, and alanine, respectively. Furthermore, mechanochemical processing of the leucine–pehnylalanine–α-dicarbonyl system led to the formation of 5-methyl-2 phenyl-2-hexenal at room temperature. This compound is generally formed via cross-aldol condensation between the Strecker aldehydes 3-methylbutanal and phenylacetaldehyde at high temperature during Maillard reaction. Moreover, no detectable acrylamide formation was observed in either asparagine–sugar or asparagine–α-dicarbonyl systems under the applied mechanochemical conditions. Thus, it has been shown that it is possible to produce Maillard reaction aromas at room temperature using a mechanochemical method while preventing acrylamide formation.

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P 08 Development and Optimization of an HPLC-RID Method for Sugar Analysis in Plant Matrices: A Tool for Acrylamide Precursor Monitoring

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Acrylamide formation in thermally processed foods is closely linked to the presence of reducing sugars (glucose, fructose, and maltose) and the amino acid asparagine via the Maillard reaction. Therefore, accurate and reliable analytical methods for sugar quantification are essential for understanding and mitigating acrylamide risk in the cereal supply chain. This study presents the development and optimization of a robust high-performance liquid chromatography method with refractive index detection (HPLC-RID) for the simultaneous quantification of key sugars relevant to acrylamide precursor monitoring, including fructose, glucose, maltose, and sucrose, as well as minor sugars and sugar alcohols.

A Box–Behnken design (BBD) coupled with response surface methodology (RSM) was employed to systematically optimize chromatographic parameters—column temperature (20–23°C), acetonitrile concentration (80–85%), and flow rate (0.7–1 mL/min)—achieving baseline separation of critical sugar pairs. The optimized conditions (20°C column temperature, 82.5% acetonitrile, 0.766 mL/min flow rate) provided satisfactory resolution (Rs > 1) for all analytes. The method was validated across relevant concentration ranges, demonstrating excellent linearity (R = 0.985–0.999) with limits of detection (LOD) and quantification (LOQ) ranging from 4.04 to 19.46 mg/L and 13.46 to 194.61 mg/L, respectively.

This validated HPLC-RID method offers a reliable, cost-effective, and environmentally friendly tool for the precise quantification of reducing sugars in various plant and food matrices. Its application extends beyond nectar analysis to cereal grains and processed foods, supporting efforts to monitor and reduce acrylamide precursors, thereby contributing to improved consumer safety and public health.

Acknowledgments: The authors gratefully acknowledge the financial support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03-33/2026-03/200032). The authors also acknowledge the support of COST Action CA21149 (ACRYRED), Reducing acrylamide exposure of consumers by a cereals supply-chain approach targeting asparagine, which enabled collaboration among the authors.

P 09 3D imaging and morphology-based descriptors for supporting acrylamide assessment in baked products

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Non-destructive assessment of acrylamide in baked products is commonly based on colour changes associated with Maillard reactions and surface browning. However, in heterogeneous bakery products, colour alone may not fully reflect the local thermal history, especially when formulation, shape, thickness and surface structure influence heat and moisture transfer.
This presentation explores the use of 3D optical imaging and morphology-based descriptors as complementary tools for the assessment of heat-induced changes in baked products. After an introduction to image-based 3D reconstruction approaches, including photogrammetry and monocular depth estimation, two biscuit case studies are presented.
In the first case study, chestnut-based biscuits with different shapes were analysed using colour, hyperspectral, thermal and 3D photogrammetric data to investigate the role of morphology in acrylamide prediction. In the second case study, multi-grain biscuits were analysed through RGB imaging and monocular depth estimation to extract colour and 3D topographical descriptors for the prediction of acrylamide.
The results indicate that 3D descriptors such as surface area, roughness, curvature, height and shape can provide useful physical information on product structure and surface heterogeneity. These features are not direct measurements of acrylamide, but they may help describe the process-related surface conditions under which acrylamide is formed. When combined with colour and other sensor-based information, 3D morphology can improve the robustness and interpretability of contactless prediction approaches for baked products.

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P 10 The Risk of Acrylamide Formation in Baby Biscuits Reformulated with Natural Sweeteners

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Baby biscuits are one of the snack foods widely consumed by toddlers and children [1]. Health authorities recommend limiting added sugars in infant and toddler food during the first two years of life [2]. For this aim, added sugar sucrose is substituted by different natural sweeteners, however, this might increase the risk of acrylamide formation in baby biscuits, which are among the major dietary sources of acrylamide for infants and toddlers. This study investigated the effect of replacing sucrose with selected natural sweeteners on acrylamide formation in baby biscuits and evaluated the potential dietary exposure of toddlers. Biscuits were prepared from whole meal flour by using apple juice concentrate, honey, grape molasses, mulberry molasses, date syrup, carob syrup, and molasses mix and baked at 220°C for 5 min. Acrylamide contents of both sweeteners and baked biscuits were determined, while sugar profiles, pH, and 5-hydroxymethylfurfural (HMF) levels were analyzed to elucidate factors influencing acrylamide formation.

Biscuits prepared with sucrose contained 26 ng/g acrylamide, whereas those made with natural sweeteners contained between 6 ng/g and 572.6 ng/g. Honey resulted in the lowest acrylamide concentration (6 ng/g), likely due to its acidic nature. In contrast, biscuits prepared with molasses and syrups contained significantly higher acrylamide levels (160–573 ng/g), exceeding the European benchmark level for infant biscuits (150 ng/g). Mulberry molasses and date syrup exhibited the highest acrylamide forming potential. Although some sweeteners contained acrylamide, most of the acrylamide detected in the final products was formed during baking. Natural sweeteners rich in reducing sugars and containing elevated levels of thermal degradation products, such as dicarbonyl compounds and HMF, exhibited greater acrylamide forming potential than refined sugar.

These findings demonstrate that replacing sucrose with certain natural sweeteners may substantially increase acrylamide formation in baby biscuits and consequently elevate acrylamide exposure in infants and toddlers. Therefore, formation of process contaminants should be considered when reformulating baby foods with natural sweeteners to reduce added sugar content.

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P 11 Assessment of Cereals for Low Free Asparagine and Acrylamide Reduction in 3D snack Products

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Asparagine is amino acid present in the proteins. The interest in plant asparagine has really taken off over the past 10 years following the report that the neurotoxin and potential carcinogen acrylamide was present in food during high-temperature processing, particularly carbohydrate-rich foods such as cereals [1]. More than two decades have now passed since the discovery of acrylamide in food and progress towards low asparagine varieties remains slow [2] It is therefore appropriate to review our current knowledge of asparagine in plants, including its content, distribution, synthesis and degradation, biological role and relationship to acrylamide formation during processing To reduce acrylamide formation in cereal foods lies in holistic approach, optimizing raw materials, refining agricultural practices, and implementing advanced food processing techniques. First is necessary to choose cereal genotype with low level free asparagine level with appropriate end use quality. It is possible by assessment diversity of asparagine in cereal species, genotypes and cereal production across different locations, screening free asparagine concentration in cereal grains. Besides it is very important to involve sustainable agronomic practices to minimize asparagine accumulation in cereal grains. Future research should focus on the implementation of advanced food processing technologies, particularly 3D food printing [3], to develop innovative cereal-based 3D-printed snack products with low level of acrylamide. Overall, a comprehensive approach is essential to successfully mitigate food safety challenges, enhance awareness regarding the health risks of acrylamide, and establish a scientific foundation for regulating free asparagine levels in raw materials.

Keywords: Acrylamide, Asparagine, Cereal Assessment, Environment, Processing Techniques

Acknowledgment: COST Action: CA21149 - Reducing acrylamide exposure of consumers by a cereals supply chain approach targeting asparagine

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P 12 Synthesis and characterization of a new acrylamide-based antioxidant for improving thermal and oxidative stability

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A novel acrylamide-based antioxidant, (*E*)-*N*-(3-hydroxypyridin-2-yl)-3-(2-nitrophenyl)acrylamide (HPNP-AM), was synthesized by an amidation reaction between 2-aminopyridin-3-ol and *trans*-2-nitrocinnamoyl chloride (68% yield; m.p. 112–114 °C) and structurally confirmed by FT-IR, ^{1}H NMR, ^{13}C NMR, and elemental analysis. The novelty of this work lies in combining the molecular design of a new phenolic acrylamide-based compound with its application-oriented evaluation as a multifunctional additive candidate for biodiesel–diesel fuel blends. The radical-scavenging capacity of HPNP-AM, assessed by the DPPH$^{\cdot}$ assay, gave an IC_{50} of 35.70 ± 0.03 µg/mL — roughly twice the activity of the reference antioxidant BHA (71.62 ± 0.14 µg/mL) — an effect attributed to the phenolic –OH and amide –NH functionalities. HPNP-AM and BHA were each incorporated at 3000 ppm into a B30D70 biodiesel–diesel blend and compared with the untreated blends. Differential scanning calorimetry (25 to −90 °C, 10 °C min^{-1}, N_2) showed the lowest crystallization onset temperature for the HPNP-AM blend (−10.78 °C), indicating a favourable shift in low-temperature behaviour. Thermogravimetric analysis (25–600 °C, 10 °C min^{-1}, O_2) gave the highest decomposition onset temperature for the HPNP-AM blend (162.56 °C), indicating improved thermal stability. FT-IR spectra of the blends confirmed the successful integration of the additive through characteristic amide and phenolic bands. Overall, the combined antioxidant, thermal, and spectroscopic results indicate that HPNP-AM is a promising, eco-friendly acrylamide-based additive for enhancing the oxidative and thermal stability of biodiesel–diesel formulations.

Keywords: acrylamide derivative; oxidative stability; biodiesel–diesel; radical scavenging; fuel additive.

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Note: *This abstract is based on work accepted for publication in BMC Chemistry (July 2026).*
A preprint (Version 1) is available at Research Square: https://doi.org/10.21203/rs.3.rs-6621619/v1

This article/publication is based upon work from COST Action ACRYRED, CA21149, supported by COST. COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.
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P 13 Plant phenotyping as a tool for breeding climate-resilient cereals with reduced potential for acrylamide formation

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The increasing frequency of drought, heat, and temperature fluctuations poses major challenges to cereal production while simultaneously influencing grain quality and food safety. One of the most important food safety concerns is the formation of acrylamide during high-temperature processing, which largely depends on the accumulation of free asparagine in cereal grains (Curtis et al., 2009). Agronomic practices, genotype, and environmental stresses interact to regulate nitrogen metabolism and free asparagine biosynthesis, making the identification of low acrylamide genotypes an important breeding objective. Recent reviews have highlighted that integrating agronomic management, plant breeding, phenotyping, and biotechnological approaches provides the most promising strategy for reducing free asparagine accumulation and, consequently, acrylamide-forming potential in cereal crops (Baldoni et al., 2026). High-throughput phenotyping technologies, including chlorophyll fluorescence imaging, multispectral and hyperspectral imaging, thermal imaging, and gas exchange analysis, enable non-destructive assessment of photosynthetic performance, stress tolerance, and physiological adaptation under diverse environmental conditions. These approaches facilitate the identification of physiological traits associated with efficient nitrogen utilization, stress resilience, and potentially lower free asparagine accumulation. Such multidisciplinary approaches improve the understanding of genotype-by-environment interactions while supporting the selection of cereal varieties that combine high productivity, stress tolerance, and reduced acrylamide-forming potential (Fiorani and Schurr, 2013). Future research should focus on combining field phenotyping platforms with molecular and metabolic analyses to identify reliable biomarkers for breeding programmes. This integrated framework will contribute to sustainable cereal production and improved food safety under changing climatic conditions.

Keywords: plant phenotyping, cereal breeding, abiotic stress, acrylamide, free asparagine, climate resilience

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P 14 Acrylamide in potato chips and bread from the Balkan market: Content and health risk assessment

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This study aimed to determine the acrylamide content in potato chips and wheat-based bread available on the Balkan market, with a particular focus on products commercialized in Kosovo and Montenegro, and to assess dietary exposure and associated health risks among different population groups. Acrylamide intake was estimated for children and adults categorized into the following age groups: 10-14, 15-17, 18-24, 25-44, 45-64, and 65-74 years. Health risk assessment was conducted by evaluating both non-carcinogenic and carcinogenic risks associated with acrylamide ingestion through the consumption of the investigated food products. Non-carcinogenic risk was assessed using the Target Hazard Quotient (THQ) and Hazard Index (HI), while carcinogenic risk was evaluated through Carcinogenic Risk (CR) values. A total of 60 potato chip samples and 25 bread samples collected from the Balkan market were analyzed. The average acrylamide concentrations were 238.38 µg/kg in potato chips and 39.45 µg/kg in bread. The measured acrylamide levels complied with the benchmark values established by Regulation (EU) 2017/2158 in 98% of potato chip samples and 85% of bread samples. Based on THQ and HI values, acrylamide exposure through the consumption of these products did not pose a significant non-carcinogenic risk for any of the investigated population groups. However, the calculated CR values indicated a potential carcinogenic risk across all age groups. The highest carcinogenic risk was observed in the youngest population group (10-14 years), reflecting their higher dietary exposure relative to body weight. Bread consumption contributed more substantially to carcinogenic risk than potato chips in most population groups, whereas individuals aged 18–24 years exhibited a higher risk associated with potato chip consumption. These findings highlight the need for continued monitoring and mitigation strategies to reduce acrylamide levels in commonly consumed cereal- and potato-based foods across the Balkan region.

Keywords: Acrylamide; potato chips; bread; Balkan market; dietary exposure; health risk assessment.

Acknowledgments: The author acknowledges COST (European Cooperation in Science and Technology) for financial support for scientific networking and dissemination activities through COST Action CA21149 (ACRYRED).

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P 15 Influence of agrotechnological and environmental conditions on free asparagine content in Czech wheat grain

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Since free asparagine is recognised as the main precursor of acrylamide in cereal-based thermally processed foods [1,2], occurrence data on free asparagine content in wheat grains and elucidation of the main driving factors behind its variations are crucial for successful mitigation of acrylamide formation. A large set (n = 709) of winter/spring common wheat and winter spelt samples, grown in line with common practises, was collected in 57 localities in the Czech Republic within the 2023 and 2024 harvest campaigns. In addition to free asparagine, the entire profile of proteinogenic free amino acids was determined and evaluated by advanced statistical methods. The free asparagine content varied between 120–755 mg/kg, 143–1256 mg/kg, and 166–1524 mg/kg in winter wheat, spring wheat and spelt wheat, respectively. Environmental and site-related factors explained most of the variation in asparagine content, with locality identified as the dominant driver. Climatic effects, such as precipitation and temperature, were strong and coherent in winter wheat, weaker in spring wheat, and not statistically influential in spelt. Soil characteristics contributed to spatial variability, whereas year and cultivation system (conventional/ecological) showed only a minor influence. These findings demonstrate that the accumulation of free asparagine in grain is governed primarily by complex site-specific environmental conditions and wheat-type-dependent physiological responses, providing a robust basis for suitable grain production.

Acknowledgements: This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic within the INTER-EXCELLENCE II programme, subprogramme INTER-COST, project No. LUC23140 (“Safe and tasty thermally processed foods prepared from low-asparagine cereals”). Scientific exchange within COST Action CA21149 Reducing acrylamide exposure of consumers by a cereals supply-chain approach targeting asparagine (ACRYRED) was also supported. The work also used data/tools/services/facilities provided by the METROFOOD-CZ Research Infrastructure (https://metrofood.cz), supported by the Ministry of Education, Youth and Sports of the Czech Republic (Project No. LM2023064). This work was also supported by the grant of Specific university research – grant No A1_FPBT_2026_001.

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P 16 Acrylamide in Coffee: Sources, Health Concerns, and Future Perspectives

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Acrylamide (AA) is a highly water-soluble organic compound that has attracted considerable scientific attention due to its toxicological significance and widespread occurrence in thermally processed foods. The International Agency for Research on Cancer (IARC) classifies acrylamide as a Group 2A compound, meaning it is probably carcinogenic to humans. Coffee, one of the most widely consumed beverages worldwide, represents a significant dietary source of acrylamide, particularly among adults and elderly populations. Acrylamide is formed during coffee roasting through complex chemical reactions, primarily involving the Maillard reaction between free asparagine and reducing sugars. The high roasting temperatures applied to coffee beans (220–250 °C) promote the development of desirable sensory characteristics, including aroma, flavour, colour, and texture, but simultaneously facilitate the formation of undesirable contaminants such as acrylamide and furans.

The concentration of acrylamide in coffee is influenced by several factors, including coffee species, bean quality, roasting conditions, and brewing methods. Although roasted and instant coffees contain varying concentrations of acrylamide, consumer exposure ultimately depends on beverage preparation practices and consumption patterns. Unlike many carbohydrate-rich foods where formulation and processing modifications have successfully reduced acrylamide formation, mitigation in coffee remains challenging due to the essential role of roasting in developing product quality attributes.

Numerous studies have investigated the mechanisms of acrylamide formation and degradation during coffee processing. Research indicates that acrylamide levels initially increase during roasting but may subsequently decrease as roasting progresses, owing to thermal degradation and participation in secondary reactions. Recent findings have highlighted the role of intermediates such as 5-hydroxymethylfurfural in acrylamide generation. Consequently, several mitigation strategies have been proposed, including the selection of high-quality green coffee beans, preferential use of Arabica varieties over Robusta, removal of defective beans, and optimization of roasting conditions with higher thermal inputs and controlled roasting profiles. These approaches aim to minimize acrylamide formation while preserving the sensory properties expected by consumers.

Despite significant advances in understanding acrylamide chemistry in coffee, further research is required to improve mitigation strategies and evaluate their industrial applicability. Continued efforts by researchers and the coffee industry are essential to reduce consumer exposure to acrylamide while maintaining coffee quality and market acceptance.

Keywords: acrylamide, coffee roasting, Maillard reaction, food safety, acrylamide mitigation, coffee processing.

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P 17 From Flour to Baked Products: The Role of Alternative Cereals in Nutritional Quality and Acrylamide Formation

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The reduction of acrylamide in cereal-based foods represents a major challenge across the grain supply chain and is a central objective of the ACRYRED network, which seeks to develop knowledge-based strategies to mitigate acrylamide formation through improved raw material selection, agricultural practices, and food processing. Since acrylamide formation is strongly influenced by the concentration of free asparagine in grains, understanding the acrylamide-forming potential of different cereal and pseudocereal flours is essential for supporting future mitigation strategies.[1] In this context, this study aimed to evaluate the relationship between flour composition, particularly free asparagine content, and acrylamide formation in cereal-based products enriched with wholegrain and alternative grains, while assessing the nutritional implications of these formulations. The study was conducted in two stages. First, a model system based on heated flours was developed using 65 samples, including refined wheat, wholegrain wheat, rye, spelt, oat, and buckwheat flours. Samples were heated at 150°C for 40 min, both alone and in the presence of water and a sucrose solution. Free asparagine was determined by HPLC-DAD, while acrylamide was quantified by HPLC-ESI-QQQ-MS/MS. Secondly, one representative sample of each cereal or pseudocereal flour was selected for the formulation of cookies and crackers. Cookies were baked at 180°C for 10 min, whereas crackers were baked at 200°C for 14 min. Nutritional composition and acrylamide content were analyzed in all formulations. In the model flour system, free asparagine ranged from 0.10 mg/g in buckwheat flour to 0.77 mg/g in rye flour. After heating, rye flours generated the highest acrylamide levels (1226–1803 µg/kg), whereas buckwheat showed the lowest values (110–227 µg/kg). A strong positive correlation was observed between free asparagine content and acrylamide formation (R^2 = 0.807), supporting the importance of precursor concentration as a key determinant of acrylamide risk. A similar, although less pronounced, trend was observed when flours were heated in the presence of hydration. Alternative cereals and pseudocereals improved the nutritional quality of cookies and crackers, particularly by increasing dietary fiber and protein contents. However, their use also modified acrylamide formation depending on flour composition and processing conditions. Acrylamide levels increased up to 1.7-fold and 2.4-fold in oat and rye cookies, respectively, and correlated significantly with precursor content (R^2 = 0.721). In crackers, acrylamide levels were higher in wholegrain wheat (600 µg/kg), spelt (478 µg/kg), and rye (791 µg/kg) than in refined wheat formulations (455 µg/kg), whereas oat (238 µg/kg) and buckwheat (174 µg/kg) crackers showed lower concentrations. These findings contribute to the objectives of ACRYRED by identifying cereal species and flour types with contrasting acrylamide-forming potential and by highlighting the critical role of free asparagine as a measurable indicator of risk. The results provide evidence that can support future breeding, raw material selection, and processing strategies aimed at reducing acrylamide formation while maintaining the nutritional benefits associated with wholegrain and alternative grain products.

Acknowledgments: This research was funded by project ACRYREVAL (PID2022- 137697NB-I00), funded by MCIN/AEI/10.13039/501100011033 and by "ERDF A way of making Europe" and is related to COST Action ACRYRED, CA21149, supported by COST (European Cooperation in Science and Technology).

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P 18 Soil-dependent effectiveness of sulfur fertilization in mitigating free asparagine accumulation in cereals and consequently acrylamide formation risk in cookies

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Studies have shown that the concentration of free asparagine in cereal grains, and consequently the risk of acrylamide formation during thermal processing, can be increased under the deficit of available sulfur in the soil, which is most commonly associated with sandiness and low organic matter content in it. Therefore, the aim of this study was to evaluate the effect of sulfur fertilization on reducing the free asparagine content in wheat, rye, and spelt grains grown in the 2022/2023 growing season, on slightly calcareous Chernozem that was moderately supplied with total nitrogen and humus, very well with available P and K, optimally supplied with total sulfur, but deficient in plant-available S (total N~2%, humus~3%, P_2O_5~34mg/100g, K_2O~32; total S~177mg/kg,d available sulfur~7mg/kg). The field experiment included one common wheat genotype (Sara), one cooking wheat genotype (Belija), two rye genotypes (Savo and BLR-8/15), and two spelt genotypes (Nirvana and Ostro). The experimental field consisted of 1) zero control plots (no fertilizer application), 2) fertilized plots with 100kgN/ha (positive control), 3) fertilized plots with N:S=100:10kg/ha. The harvested grains were analyzed for free asparagine, while whole-grain flours of these genotypes were used to prepare cookies baked at 180°C for 10 minutes and acrylamide was analyzed in them. In common wheat Sara and cooking wheat Belija, nitrogen fertilization increased free asparagine concentration by 15% and 17%, respectively, compared to the unfertilized control. The free asparagine level increased in rye by 18% and 9% in BLR-8/15 and Savo, respectively, while the average increase in spelt was around 10%. The addition of 10 kg/ha of sulfur reduced free asparagine concentration by an average of approximately 7% compared with nitrogen only fertilization across wheat, rye, and spelt grains. The relatively small reduction in free asparagine content observed following sulfur fertilization may be explained by sulfur mineralization from the relatively high organic matter content of the soil, which could have partially compensated for the limited availability of plant-available sulfur. On the other hand, acrylamide content was reduced by 11% and 67.6% in the wheat genotypes Sara and Belija, respectively. In rye genotype BLR-8/15, acrylamide content decreased by 3%, while a 14% reduction was observed in the spelt genotype Ostro. Overall, these findings indicate that the effectiveness of sulfur fertilization in reducing free asparagine accumulation largely depends on soil characteristics, particularly its type and structure, as well as the content of organic matter in it. Furthermore, although free asparagine is the principal precursor of acrylamide, we can conclude that the pathway of acrylamide formation is complex and multifactorial.

Acknowledgments: This research was supported by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia (Grant No. 451-03-33/2026-03/200040), the European Union—NextGenerationEU and COST Action CA21149.

P 19 Reducing Acrylamide in Cereal-Based Foods: Current Mitigation Strategies, Risk–Benefit Evaluation, and Regulatory Perspectives

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Background. Acrylamide is a process-induced contaminant that forms in cereal-based foods during high-temperature cooking processes such as baking, roasting, and frying. Cereal products are among the major contributors to dietary acrylamide exposure due to their widespread consumption. Acrylamide formation is influenced by the concentration of precursor compounds, particularly free asparagine and reducing sugars, the food matrix, ingredient composition, and processing conditions. Consequently, effective mitigation strategies are essential to reduce consumer exposure while preserving food quality and safety.
Aim of the Study. This review aims to summarize current knowledge on acrylamide formation in cereal-based foods, evaluate mitigation strategies, examine risk–benefit considerations associated with innovative cereal formulations, and highlight the recommendations provided by the U.S. Food and Drug Administration (FDA) for acrylamide reduction.
Methodology. A comprehensive review of the scientific literature and FDA guidance documents was conducted. The evidence was analyzed to identify the main factors influencing acrylamide formation, the effectiveness of mitigation approaches, and the implications of ingredient selection, product reformulation, and thermal processing on acrylamide levels in cereal-based foods.
Results and Discussion. The review demonstrates that acrylamide formation is primarily determined by the availability of free asparagine and reducing sugars, together with processing temperature and duration. Strategies such as optimizing baking time and temperature, selecting raw materials with lower precursor concentrations, modifying formulations, applying enzyme treatments (e.g., asparaginase), and providing appropriate cooking instructions can substantially reduce acrylamide formation. FDA guidance recommends that manufacturers routinely monitor acrylamide levels and evaluate reduction strategies while ensuring that chemical and microbiological safety, nutritional quality, and sensory properties are maintained. The incorporation of novel ingredients into cereal products should be accompanied by a risk–benefit assessment, as healthier or more sustainable formulations may alter acrylamide-forming potential.
Conclusions. Reducing acrylamide in cereal-based foods requires an integrated approach involving ingredient selection, optimized processing conditions, and continuous product evaluation. FDA recommendations provide a practical framework for manufacturers to minimize acrylamide formation without compromising product quality or consumer acceptance. Future research should focus on developing innovative cereal formulations that achieve both nutritional improvements and reduced acrylamide levels, thereby contributing to safer and healthier food products.
Keywords: Acrylamide; Cereal-based foods; Food safety; Thermal processing; Mitigation strategies; FDA guidance; Risk–benefit assessment; Food contaminants; Baking; Food quality.

References: https://www.fda.gov/food/process-contaminants-food/acrylamide

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P 20 Effect of foliar sulfur application on free asparagine accumulation and acrylamide formation in maize products

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Acrylamide is a heat-induced process contaminant formed mainly from free asparagine during thermal processing of carbohydrate-rich foods [1]. Reducing free asparagine accumulation in maize grain before processing represents a promising strategy for mitigating acrylamide formation in maize-based foods. The aim of this study was to examine how foliar sulfur fertilization (F1 - NaHS and F2 - Chopin Evolution Nitrosulfate) and sulfur-based herbicides (H1 - Motivell Nicosulfuron and H2 - Equip Foramsulfuron) affected the accumulation of free asparagine in maize grain and how this influenced the formation of acrylamide in crackers and chips.

Field experiments were conducted over two growing seasons, using four different maize hybrids recently developed at the Maize Research Institute Zemun Polje, Serbia. Recommended foliar concentrations of two sulfur-based herbicides and two fertilizers were applied separately and in combination. Free asparagine content was determined in maize flour samples, while crackers and chips were prepared from flour of the most responsive maize genotype (ZP735) to evaluate acrylamide formation after thermal processing.

The free asparagine content in the investigated maize flour samples ranged from 330 to 753 mg/kg. Sulfur fertilizers and herbicides showed genotype dependent effects, resulting in both increases and decreases depending on the treatment and genotype combination. Compared with the untreated control, free asparagine content in genotype ZP735 decreased by 14.8 and 15.2% in the first year and by 21.6 and 19.0% in the second year after the selected treatments (F2 and F2-H1, respectively). The strongest response was observed in the same genotype, where free asparagine decreased by up to 24% in the second year under combined sulfur fertilizer and herbicide application (F1-H2). As this genotype showed the most pronounced response, flour from ZP735 was selected for processing into crackers and chips. The highest acrylamide reduction of 45% was observed in crackers prepared from second-year maize flour treated with F2-H1. This reduction (from 605 to 333 µg/kg) brought the acrylamide content in crackers below the EU benchmark level, while chips showed a maximum reduction of 33% but still remained approximately 2-fold above the benchmark value.

The results demonstrate that the interaction between genotype, treatment and growing season significantly affected free asparagine accumulation. Although reducing free asparagine generally lowered acrylamide formation, the relationship was product dependent and not directly proportional. This indicates that additional factors should be considered when developing strategies to mitigate acrylamide formation.

Acknowledgments: This study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03-33/2026-03/200040), Bilateral project of the Republic of Serbia and the Republic of Turkey and COST Action ACRYRED (CA21149)

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P 21 Chemical and Processing Aspects of Acrylamide Formation and Mitigation in Cereal-Based Food Products

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Acrylamide formation in cereal-based food products remains an important food-safety concern, mainly because this contaminant is generated during high-temperature processing through Maillard-type reactions involving free asparagine and reducing sugars. Cereal-derived foods such as bread, biscuits, breakfast cereals, crackers, and toasted or baked grain-based products represent relevant dietary sources of acrylamide exposure. Therefore, a clearer understanding of the chemical and processing factors that influence acrylamide formation is essential for developing effective and practically applicable mitigation strategies [1-3].

This contribution focuses on the chemistry and processing-related determinants of acrylamide formation in cereal-based food matrices. Particular emphasis is placed on the role of free asparagine as the main amino acid precursor, the contribution of reducing sugars, and the influence of key technological parameters such as baking temperature, heating time, moisture content, pH, recipe formulation, and raw material composition. Processing-oriented mitigation options, including precursor control, ingredient selection, optimization of thermal treatment, and formulation adjustment, are considered in relation to their potential to reduce acrylamide formation while preserving product quality and consumer acceptability [4].

Analytical monitoring also represents a central component of acrylamide risk management. Reliable chemical analysis is necessary for evaluating acrylamide levels in cereal-based products, comparing processing conditions, and verifying the effectiveness of mitigation approaches. From this perspective, the integration of precursor chemistry, thermal processing control, and analytical assessment may support more targeted strategies for reducing acrylamide exposure in cereal-derived foods [5].

Overall, this chemistry-and-processing perspective aims to contribute to the ACRYRED framework by linking acrylamide precursor formation, technological conditions, analytical monitoring, and practical mitigation pathways relevant to cereal-based food production.

Acknowledgments: This contribution is based upon work from COST Action ACRYRED, CA21149, supported by COST (European Cooperation in Science and Technology).

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P 22 Economic Assessment of Acrylamide Mitigation across the Cereal Supply Chain: A Case Study from the Republic of Kosovo

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Acrylamide is a process contaminant formed during high-temperature cooking of cereal-based foods and represents an important food safety concern due to its potential adverse health effects. While considerable research has focused on analytical determination and mitigation technologies, limited attention has been given to the economic implications of implementing acrylamide mitigation measures across the cereal supply chain, particularly in developing and transition economies [1].
This study presents a preliminary economic assessment of acrylamide mitigation throughout the cereal supply chain in the Republic of Kosovo, covering the major stakeholders from seed suppliers and farmers to grain storage facilities, milling companies, ingredient suppliers, cereal manufacturers, packaging, distribution, retailers, and consumers. The assessment is based on available scientific literature, European Union recommendations, industry reports, and expert evaluation of the current cereal production and processing system in Kosovo [2-3].
The analysis identifies the principal economic factors associated with mitigation strategies, including investments in raw material selection, improved agricultural practices, storage management, process optimization, analytical monitoring, quality assurance systems, and consumer communication. Particular attention is given to the potential costs for small and medium-sized enterprises, which constitute the majority of Kosovo's cereal processing sector, as well as the long-term benefits related to improved food safety, regulatory compliance, market competitiveness, consumer confidence, and public health protection [4].
The findings suggest that although initial implementation of acrylamide mitigation measures may require moderate financial investment, many interventions can be integrated into existing quality management systems with relatively low additional costs. Furthermore, coordinated collaboration among academia, food industry, governmental authorities, and regulatory agencies is essential for supporting sustainable implementation of mitigation strategies [5].
This work provides the first country-specific overview of the potential economic impact of acrylamide mitigation within Kosovo's cereal supply chain and contributes to the broader objectives of COST Action CA21149 Working Group 4 by supporting evidence-based decision-making and future supply chain strategies for acrylamide risk reduction.

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P 23 Effect of Sulphur and Selenium foliar fertilization on grain quality in bread wheat (*Triticum aestivum* L.)

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Improving the nutritional quality of wheat while maintaining crop performance is a major challenge for sustainable cereal production. Agronomic biofortification, based on the targeted application of mineral fertilizers during crop growth, has emerged as a promising strategy to enhance grain nutritional value without compromising productivity.

This study evaluated the combined effects of foliar sulphur (S) and selenium (Se) applications on grain quality traits in two contrasting bread wheat cultivars (Bologna and Sieve) grown under rainfed Mediterranean conditions. A two-year field experiment was conducted using three S application rates (0, 3.2 and 6.4 kg S ha^{-1}) and five Se rates (0, 2.57, 5.14, 10.27, and 20.54 g Se ha^{-1}). Grain yield, protein composition, free asparagine, phytic acid, mineral bioavailability and dough rheological properties were assessed.

Foliar fertilization had no significant effect on grain yield in either variety across the two growing seasons. In contrast, grain quality traits responded markedly to foliar fertilization. Sulphur was the main factor controlling free asparagine accumulation, accounting for more than 80% of the observed variability, and induced a marked reduction in both cultivars, with a stronger response in the old cultivar Sieve than in the modern cultivar Bologna. Selenium further decreased free asparagine under adequate sulphur supply, suggesting a complementary effect between the two nutrients. Sulphur also shifted gluten composition by decreasing gliadin and increasing glutenin content, improving dough quality. Selenium fertilization was associated with reduced phytic acid concentration and significantly lower Phy:Se, Phy:Fe and Phy:Zn molar ratios, indicating enhanced mineral bioavailability. Sieve exhibited significantly higher albumin concentrations than Bologna. Albumin decreased with S application, particularly at the highest S level, and to a lesser extent with high Se levels. Globulin content was also affected by both S and Se fertilizations. In particular, S application reduced globulin concentration, with a stronger response in the old cultivar Sieve, highlighting genotype-dependent differences in protein composition.

The combined foliar application of sulphur and selenium effectively reduced free asparagine while simultaneously improving the nutritional and technological quality of wheat grain without affecting yield. These findings highlight agronomic biofortification as a practical strategy to mitigate acrylamide risk in cereal-based foods while enhancing wheat quality.

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P 24 Protein and Free Amino Acid Profiles in Spelt vs. Bread Wheat: A Comparative Evaluation of Quality and Processing Potential

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The two-year study (2021, 2022) explored the differences and similarities between spelt and common bread wheat by analyzing 12 distinct varieties of each species. To ensure a representative sample set, varieties were selected using cluster and principal component analysis based on genetic diversity via a 25K SNP array, protein content, and breadmaking quality traits. The core focus of the research was to evaluate protein content and composition, assessing their overall significance for the processing industry. According to the two-factor analysis of variance, spelt exhibited a higher average protein content and gliadin/glutenin ratio, but lower levels of glutenin and unextractable polymeric protein (UPP%). This specific composition indicates a weaker, softer dough structure compared to common wheat. The environmental impact of the vintage year significantly altered the protein composition of spelt, whereas in common wheat, it primarily affected the overall protein content and water-soluble protein fractions. On the other hand, the specific variety had a significant effect on both protein content and the Glu/Gli ratio across both cereal species. Further analysis using the Tukey test revealed that only protein content showed significant variations among individual spelt varieties. In contrast, common bread wheat displayed significant inter-varietal differences across multiple parameters, including the Glu/Gli ratio, UPP%, and glutenin content. This divergence suggests that the bread wheat varieties in this sample set possess greater genetic diversity regarding their protein composition.The investigation also measured free asparagine content, which was generally higher in spelt and demonstrated greater intraspecific variability, though total levels remained low in both species. In common wheat, the crop year had a substantial impact on asparagine levels while the genotype did not, highlighting the dominant role of environmental factors. Ultimately, the research demonstrates that both variety and seasonal weather conditions are critical factors driving the development of protein content and quality characteristics in these grains. These insights deliver a valuable baseline for optimizing future breeding programs and agricultural production strategies tailored to food industry standards.

Acknowledgments: This research was funded by the Hungarian National Research, Development, and Innovation Office under Grant Agreements No. K135211 and K135343, as part of the project "Exploring of the genetic, compositional and processing potentials of spelt," as well as under project No. TKP2021-NKTA-06. The research collaboration was also supported by COST Action ACRYRED (CA21149), titled "Reducing acrylamide exposure of consumers by a cereals supply-chain approach targeting asparagine.

P 25 Variability of Free Asparagine Content in Naked Oat *(Avena nuda)* Grain: Effects of Genotype, Location, and Climatic Factors

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Naked oat is characterized by higher concentrations of free asparagine (Asn) compared to other cereals, which is of particular relevance to acrylamide formation during thermal processing. In a two-year study (2023–2024), the variability of free Asn content was evaluated in 40 naked oat samples originating from 12 locations and eight cultivars. Statistical evaluation was based primarily on four locations and six cultivars represented by at least three samples each. Ten factors were assessed, including year, cropping system, location, cultivar, and temperature and precipitation characteristics of the growing season. The most significant factor influencing Asn content was mean temperature during the second quarter of the growing season (Q2), followed by mean temperature across the whole growing season. Higher Asn concentrations observed in 2023 were likely associated with a lower mean growing-season temperature (13.2 °C) compared to 2024 (15.5 °C). The effect of precipitation was not statistically significant; in 2024, a weak, non-significant trend suggested higher Asn content at higher precipitation totals, whereas this relationship was not confirmed in 2023. No significant overall effect of cultivar on Asn content was detected. A difference between individual cultivars was found only between Patrik and Amant, though interpretation for Amant is limited by the low number of samples (n = 2). Based on the results obtained, no clear agrotechnical recommendations for reducing Asn accumulation in naked oat grain can yet be formulated. The decisive factors were predominantly climatic in nature and difficult to influence through cultivation practices. Further multi-year monitoring of a larger set of cultivars and locations will be necessary to develop more reliable recommendations.

Acknowledgments: This work was supported by the Ministry of Education, Youth and Sports of the Czech Republic (Project No. LUC23140) and COST Action CA21149 ACRYRED.

P 26 Acrylamide Reduction in Potato Snacks by Adding Thiol Compounds

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The Maillard reaction provides desirable colour and aroma compounds, but it also leads to the formation of acrylamide, a probable human carcinogen (IARC, 1995). Potato-based foods pose a significant risk for acrylamide formation since they contain high levels of asparagine, which readily reacts with reducing sugars. There are several methods to reduce acrylamide in food, including the incorporation of thiol groups into the food formulation. The presence of an α,β-unsaturated carbonyl group in acrylamide makes it readily available for nucleophilic interactions with thiol compounds. Based on this approach, this study investigates the effects of different concentrations of glutathione (GSH) and cysteine, as thiol compounds, in formulated potato snacks alongside their corresponding impacts on sensory attributes and aroma profile. Additionally, the underlying interaction mechanisms were studied using high-resolution mass spectrometry (HRMS). Different concentrations of GSH and cysteine (0.1 %, 0.25 %, 0.5 %, 1.0 %) were incorporated into the potato dough to make formulated potato snacks. Uniform, disk-shaped snacks were obtained from the potato dough, which were then subjected to drying at 90°C for 15 minutes and baking at 180°C for 3 minutes. Subsequently, acrylamide, aroma, and sensory analysis were performed on the formulated potato snacks. Incorporating GSH to the potato formulation with a concentration of 0.5% and 1% decreased acrylamide formation by 59.8% and 71.2%, respectively. Similarly, 0.5% cysteine addition achieved a prominent reduction of 80.2%. When HRMS results were examined, acrylamide-cysteine adducts and acrylamide-GSH adducts could not be confirmed whereas oxidized form of cysteine and GSH were detected. These results indicate that acrylamide formation is prevented because carbonyl compounds preferentially react with available thiol groups rather than the amine group of asparagine, thereby blocking the Schiff base formation step. Sensory analysis was performed with GSH (0.5 and 1.0%) and cysteine (0.5 and 1.0%) containing potato snacks. Taste, appearance, and odour were evaluated by 80 untrained panelists. There were no significant differences in appearance between the control and GSH containing potato snacks. Conversely, the cysteine containing potato snacks received significantly lower evaluations for their odour and taste attributes. According to aroma profiles, GSH containing potato snacks showed similar aroma profile to the control chips, which was consistent with the sensory analysis. In contrast, cysteine-containing snacks deviated significantly from them, a difference primarily driven by the higher concentrations of thiazoles and thiophenes. On the other hand, typical Maillard reaction markers such as pyrazines and Strecker aldehydes were relatively more abundant in the GSH containing snacks and the control group. These results imply that the presence of cysteine specifically inhibited the formation of Maillard aroma compounds. Overall, both GSH and cysteine successfully mitigate acrylamide when applied at optimal concentrations, with GSH being the more promising option regarding sensory attributes.

Acknowledgments: This work was supported by The Scientific and Technological Research Council of Turkey under grant number 122N952 and by the Scientific Research Projects Coordination Unit of Hacettepe University under grant number FHD-2024-21547.

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P 27 Targeted Delivery of Encapsulated Polyphenol-rich Artichoke Extract for Acrylamide Mitigation in Cereal Based Food Systems

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Acrylamide remains one of the most important process-induced contaminants in cereal-based foods, prompting continued efforts to develop effective and sustainable mitigation strategies without compromising product quality. Plant bioactives have attracted increasing attention due to their antioxidant properties and their potential to interfere with pathways involved in acrylamide formation. However, their thermal instability during baking may limit their practical effectiveness, highlighting the need for improved delivery approaches [1]. This ongoing research explores the sustainable valorization of globe artichoke (*Cynara scolymus* L.) byproducts through the green recovery of polyphenol-rich extracts and their subsequent application as natural acrylamide mitigating ingredients. Microwave-assisted extraction using aqueous and hydroethanolic systems has been employed to recover phenolic compounds from different artichoke byproducts, followed by preliminary characterization through total phenolic content, antioxidant activity, and HPLC phenolic profiling. Based on preliminary characterization, leaf-derived extracts were selected for subsequent encapsulation owing to their superior phenolic composition and antioxidant potential. The next phase focuses on the microencapsulation of selected polyphenol-rich extracts by spray drying using food-grade wall materials (Maltodextrin and Gum Arabic) to improve thermal protection and enable controlled release during baking. 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 proposed strategy is expected to improve the availability of bioactive compounds at critical stages of thermal processing, thereby enhancing their interaction with Maillard reaction intermediates associated with acrylamide generation [2]. 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 [3]. This strategy seeks to balance ingredient design and thermal processing control by offering bioactive compound delivery and process-stage functionality. By integrating green extraction technologies, sustainable byproduct valorization, encapsulation, and food processing, this work presents an interdisciplinary framework that combines circular bioeconomy principles with food safety innovation. The outcomes are expected to contribute to the development of naturally derived mitigation strategies that support safer cereal products while promoting the high value utilization of agro-industrial residues.

Acknowledgments: This contribution is based upon work from COST Action ACRYRED (CA21149), supported by COST (European Cooperation in Science and Technology)

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P 28 Balancing Yield, Quality, and Acrylamide Risk in Winter Wheat under Variable Environments

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Alongside the challenge of balancing grain yield and end-use quality in wheat, increasing attention is being given to free asparagine, a key precursor of acrylamide formed via the Maillard reaction during high-temperature processing. Its accumulation is highly environment-dependent and typically increases under stress conditions, particularly when nitrogen is abundant but sulfur is limiting, or under drought and heat stress.
To investigate these interactions, winter wheat genotypes were evaluated across four locations and two growing seasons in Croatia. Environmental differentiation along PC2 separated favourable conditions - observed in Osijek, Tovarnik, and Kutjevo in 2025, characterised by higher yield, plant height, and starch content - from less favourable environments, including Zagreb in both seasons and Tovarnik and Kutjevo in 2024. These less favourable environments, associated with greater abiotic stress, are likely to promote higher free asparagine accumulation, reinforcing the inverse relationship between stress resilience, grain composition, and processing safety. Seasonal variation in temperature and precipitation, particularly the more favourable moisture distribution in 2024/2025, played a key role in shaping both agronomic performance and metabolic profiles.
Genotypes formed distinct clusters, with Kraljica and Viktorija clearly separated, suggesting differential sensitivity to environmental stress and nitrogen–sulfur balance. Correlation analysis revealed positive associations among quality traits but negative relationships with grain yield, while also indicating that traits linked to protein composition may coincide with elevated asparagine levels under stress conditions, highlighting an additional breeding constraint related to food safety.

Acknowledgments: We acknowledge COST Action CA21149.

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P 29 Underexplored Traditional Turkish Foods: Filling Knowledge Gaps in Acrylamide Occurrence and Dietary Exposure

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Many research has focused on major dietary sources of acrylamide, such as potato products, coffee, breakfast cereals and commercial bakery products, but traditional foods are still relatively underrepresented in the scientific literature, despite their importance in local dietary habits. Previous studies in Türkiye have indicated considerable variability in acrylamide levels in various food groups. A large survey of 311 food samples throughout the country showed significant differences between processed and traditional foods and highlighted the importance of continuing surveillance of acrylamide exposure through the diet [1]. The levels of acrylamide in traditional simit samples were in the range of 11.8-179 µg/kg, in traditional breads 11.8-69.3 µg/kg, and up to 527 µg/kg in deep-fried traditional desserts [2]. In addition, dietary exposure assessments estimated the total acrylamide intake in the Turkish population to be between 0.85 and 2.81 µg/kg body weight/day for the consumption scenarios, indicating that dietary habits could potentially have a significant impact on the levels of exposure [3].

Despite these valuable contributions, current knowledge remains fragmented. Existing investigations have primarily focused on selected traditional breads, simit varieties, desserts, and a limited number of meat-based traditional foods [2,4]. However, Türkiye possesses more than 800 geographically indicated traditional foods representing a remarkable diversity of raw materials, formulations, and processing techniques [2]. In contrast, limited information is available for many traditional products, including tarhana and tarhana-based foods, erişte (traditional Turkish noodles), bulgur-based snacks, regional bakery products, fermented cereal-based foods, traditional cereal mixtures such as kavut, and numerous geographically indicated local specialties. These products are characterized by different processing conditions and ingredient compositions which could influence acrylamide formation but received considerably less attention in the current literature. Moreover, little is known about how traditional processing conditions and artisanal production practices affect acrylamide formation.

This overview points out a major gap in the science of acrylamide. Expanding occurrence studies to understudied traditional Turkish foods would enhance dietary exposure assessments, lessen present uncertainties of exposure estimation, aid in identification of high-risk products and support the development of targeted mitigation strategies.

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P 30 Asparagine distribution in commercial wheat flours produced using different milling technologies and its relation to acrylamide formation in bread

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Free asparagine (Asn) is the principal precursor of acrylamide, a process contaminant formed during the Maillard reaction when cereal products are baked at high temperatures. The concentration of Asn in wheat-based products is therefore considered one of the key factors determining the acrylamide-forming potential of bread. Previous studies have demonstrated that Asn is unevenly distributed within the wheat grain and is predominantly concentrated in the outer layers (bran and aleurone), whereas the starchy endosperm contains considerably lower amounts. Consequently, flour type and extraction rate, which determine the proportion of bran particles in flour, are expected to significantly affect Asn concentration and, potentially, acrylamide formation in bakery products. However, information on the variability of Asn content in commercial flours produced under industrial milling conditions remains limited.

The aim of this study was to determine the variability of Asn content in two types of commercial wheat flour (type 500 and type 750) produced in industrial milling company. In addition, technological quality parameters, laboratory baking test, and acrylamide content in bread were evaluated.

Protein content, ash content, water absorption, and rheological properties of dough were determined acc. to the appropriate ISO Standards. Asn content was determined using the free amino acid analysis method described by Świder et al. (2020). The analysis was performed by UHPLC-MS/MS. Laboratory baking tests were carried out according to the procedure described by Wiwart et al. (2023). Acrylamide content was determined by GC-MS following bromination acc. to Roszko et al. (2020).

The tested flour samples varied in protein content (9.9–10.4% d.m.), ash content (0.38–0.85% d.m.), and Asn content (176–1154 mg/kg). Water absorption ranged from 55.5 to 59.2%. Bread produced during the laboratory baking test showed proper appearance, while loaf volume ranged from 271 to 368 cm^3. Acrylamide content remained relatively low, ranging from 11 to 19 µg/kg.

Flour type significantly influenced the chemical characteristics of the products. Wheat flour type 750 was characterized by higher protein content than flour type 500 (11.7 vs. 10.9% d.m.), higher ash content (0.76 vs. 0.45% d.m.), and substantially higher Asn content (707 vs. 385 mg/kg). Type 750 flour also exhibited greater water absorption (58.1 vs. 56.4%), whereas bread baked from this flour had lower loaf volume than bread produced from type 500 flour (283 vs. 336 cm^3). Despite considerable differences in Asn concentration between flour types, no significant differences were observed in the acrylamide content of the corresponding breads.

The results demonstrate that flour type and industrial milling technology markedly affect the accumulation of Asn in commercial wheat flours. However, no significant differences in acrylamide content were observed in breads produced from the different flour types under standardized laboratory baking conditions.

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P 31 From Gene to Grain: A Virtual Mobility Initiative Promoting Integrated Approaches to Free Asparagine and Acrylamide Mitigation

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Acrylamide is a process contaminant formed during the high-temperature processing of cereal-based foods, with free asparagine recognized as its main precursor in wheat and other cereals. Reducing acrylamide formation therefore requires an integrated understanding of the genetic, physiological, agronomic, and technological factors regulating free asparagine accumulation along the cereal supply chain.

Within the framework of the COST Action ACRYRED (CA21149), the Virtual Mobility initiative *'From Gene to Grain: Integrated Approaches to Free Asparagine and Acrylamide Mitigation'* was developed to strengthen interdisciplinary collaboration and knowledge exchange through a coordinated series of scientific webinars. The initiative brought together researchers from different European institutions and disciplinary backgrounds, providing a platform for discussing complementary approaches to acrylamide mitigation and fostering interaction between early-career and senior scientists.

The webinar series addressed key aspects of free asparagine research, including the genetic and molecular regulation of its accumulation, genotype-by-environment interactions, metabolomic approaches, agronomic management and nutrient biofortification strategies, cereal grain quality, and the relationship between crop management, processing, and acrylamide formation. By integrating expertise across plant genetics, crop physiology, agronomy, grain quality, and food safety, the initiative promoted a systems-level perspective on reducing acrylamide risk throughout the cereal value chain.

Beyond scientific dissemination, the Virtual Mobility contributed to capacity building by encouraging discussion, networking, and the exchange of methodologies among Working Group members. Webinar recordings and supporting materials provide a lasting resource for the Action, while the interactions generated during the series have strengthened scientific connections and identified opportunities for future collaborative research. Overall, the initiative demonstrates how structured virtual activities can effectively support interdisciplinary research coordination and contribute to the objectives of ACRYRED by promoting integrated strategies for safer and more sustainable cereal production.

Acknowledgments: This work was carried out within the framework of COST Action CA21149 (ACRYRED – Reducing acrylamide exposure of consumers by a cereals supply-chain approach targeting asparagine) and was supported by the COST Association – European Cooperation in Science and Technology through a Virtual Mobility Grant awarded to Andrea Tafuri.

P 32 Acrylamide Formation in Protein-Enriched Corn Extrudates: Effects of Pea Protein, Sugars, and Processing Conditions

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Corn-based extrudates are widely consumed snacks, but concerns over process contaminants such as acrylamide have increased with the use of protein-rich ingredients like pea protein isolate (PPI). Although PPI enhances nutritional value, its impact on acrylamide formation, alongside flavour and sensory properties, remains insufficiently understood. This study primarily investigated the effects of enzymatic pretreatment, pea flour incorporation, and liquid feed composition on acrylamide formation in cornmeal–PPI extrudates, while also examining associated physicochemical, volatile, and sensory changes.

PPI and cornmeal were enzymatically pretreated using Flavourzyme and amylase prior to extrusion. Extrudates formulated with treated materials or pea flour were produced using different liquid feeds, including water, NaCl, $NaHCO_3$, sugar solutions, and their combinations. Acrylamide content was quantified alongside physical, sensory, and volatile profile analyses.

Acrylamide levels ranged from 23 to 42 µg/kg across all samples, indicating generally low formation under the applied extrusion conditions. A significant increase in acrylamide was observed only in formulations containing pea flour, suggesting a higher availability of precursors in less refined protein sources. Neither enzymatic pretreatment nor most liquid feed variations caused a substantial rise in acrylamide. Notably, sugar addition, either directly or via enzymatic hydrolysis, did not elevate acrylamide levels despite enhancing Maillard-driven flavour.

Multivariate analysis revealed that alkaline conditions promoted pyrazine formation, whereas sugar favoured aldehydes and ketones, contributing to improved aroma without increasing acrylamide. Sugar-containing formulations also altered physical properties, increasing bulk density and reducing hardness, while enhancing toasted aroma intensity. Sensory evaluation showed improvements in flavour quality without changes in bitterness or undesirable texture attributes.

Overall, the results demonstrate that acrylamide formation in protein-enriched corn extrudates can be effectively controlled through formulation strategies. The incorporation of sugars and enzymatic modification improved sensory quality without promoting acrylamide formation, whereas the use of pea flour requires careful consideration due to its contribution to higher acrylamide levels.

Acknowledgments: This research was partly supported by The Scientific and Technological Research Institution of Türkiye (TUBITAK) in the frame of 2219 – International Postdoctoral Research Fellowship Program for Turkish Citizens.

P 33 Biomass-Derived Functional Materials as Emerging Sustainable Tools for Acrylamide Mitigation in Cereal Processing: A Literature Perspective

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Acrylamide is a process contaminant formed mainly through the Maillard reaction between free asparagine and reducing sugars during high-temperature processing of cereal-based foods. Considerable progress has been achieved through agronomic practices, recipe reformulation, enzyme treatment, and optimization of processing conditions. Nevertheless, there remains a need for innovative, sustainable, and circular-economy approaches that complement existing mitigation strategies. This poster provides a literature-based overview of the potential role of biomass-derived functional materials in future acrylamide mitigation strategies, highlighting opportunities where knowledge from biomass valorization, adsorption science, and surface chemistry could contribute to food-processing research.Recent studies have demonstrated that agricultural by-products can be converted into activated carbons and functional biochars possessing highly tunable pore structures and surface chemistries. Although these materials have been extensively investigated for environmental remediation, gas capture, and adsorption of organic contaminants, their application within food-processing systems remains largely unexplored.
The literature suggests several promising research directions, including:
• selective adsorption of acrylamide precursors from food-processing streams,
• immobilization of catalytic or enzymatic systems for precursor removal,
• incorporation into sustainable filtration or purification processes,
• development of recyclable functional materials for food-processing applications,
• integration of biomass valorization into circular food-production systems.
Surface chemistry, pore architecture, oxygen-containing functional groups, and controlled modification of biomass-derived carbons may provide opportunities for designing next generation materials compatible with food-processing technologies. Rather than proposing immediate industrial implementation, this work identifies knowledge gaps and future interdisciplinary research opportunities connecting food chemistry, material science, and sustainable processing. Such collaborations could expand the toolbox available for acrylamide mitigation while simultaneously promoting biomass waste valorization and circular bioeconomy principles. Biomass-derived functional materials represent an emerging research direction that deserves greater attention within acrylamide mitigation research. Establishing collaborations between experts in food chemistry, cereal processing, adsorption science, and materials engineering may accelerate the development of sustainable technologies capable of complementing existing mitigation strategies while supporting circular resource utilization.

Keywords: Acrylamide; Cereal processing; Biomass valorization; Activated carbon; Adsorption; Sustainable food processing; Circular bioeconomy

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Title: ACRYRED FINAL GENERAL MEETING; PROCEEDINGS

Editor: Zuzana Ciesarová

Publisher: National Agricultural and Food Centre, Lužianky, Slovak Republic

Edition: first

Year of Publication: 2026

Format of Publication: e-document online - PDF

ISBN 978-80-69227-08-8
EAN 9788069227088

This article/publication is based upon work from COST Action ACRYRED, CA21149, supported by COST. COST (European Cooperation in Science and Technology) is a funding agency for research and innovation networks. Our Actions help connect research initiatives across Europe and enable scientists to grow their ideas by sharing them with their peers. This boosts their research, career and innovation.

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