



# ACRYRED

## Deliverable 4.2

### Draft agenda for the next 5 years for cereal supply chain economy and consumer behaviour research

Project Name	ACRYRED
Contractual Delivery Date	30.06.2024
Actual Delivery Date	30.10.2025
Working Group	WG4
Authors	Tanya Curtis [Curtis Analytics limited] - WG3 Leader
Grant Period	#3

## Table of Contents

<b>Authors and Reviewers</b> .....	<b>2</b>
<b>1. Introduction</b> .....	<b>3</b>
<b>2. Exposure Data and Risk Evaluation</b> .....	<b>3</b>
<b>EU Benchmark Levels (Regulation 2017/2158)</b> .....	<b>3</b>
<b>4. Summary: Acrylamide Toxicological Risk Assessment</b> .....	<b>4</b>
<b>4.1 Risk Assessment Process:</b> .....	<b>4</b>
Hazard Identification: .....	4
Exposure Quantification: .....	4
<b>5. Strategic Pillars:</b> .....	<b>4</b>
<b>1. Regulatory Expansion and Immediate Actions</b> .....	<b>4</b>
<b>2. Strategic Workstream I: Organic Supply Chain Optimisation</b> .....	<b>4</b>
<b>3. Strategic Workstream II: Organic Enzyme Innovation</b> .....	<b>5</b>
<b>4. Strategic Workstream III: Pellet Input Control</b> .....	<b>5</b>
<b>6. Conventional Manufacturer Strategy</b> .....	<b>5</b>
Short-Term.....	5
Medium-Term .....	5
Long-Term Strategy: Genetic Improvement and Supply Chain Integration .....	5
Surveillance and Regulatory Refinement for Acrylamide Mitigation .....	6
<b>Conclusions:</b> .....	<b>6</b>
<b>7. Additional research activities and presentations over 2025</b> .....	<b>7</b>
<b>Legal Disclaimer</b> .....	<b>7</b>

## Authors and Reviewers

Main Responsible		
Organization	Name	Mail
Curtis Analytics Limited	Tanya Curtis	tanya.curtis@curtisanalytics.co.uk
Author(s) / Contributor (s)		
Organization	Name	Mail




## 1. Introduction

Acrylamide is a neurotoxic and potentially carcinogenic compound formed during high-temperature cooking of carbohydrate-rich foods. Although the human body has detoxification mechanisms, acrylamide's genotoxicity has led to its classification as a processing contaminant under EU law. This classification requires mitigation in accordance with the ALARA (As Low As Reasonably Achievable) principle.

The **EU Commission Regulation (EU) 2017/2158** establishes mitigation measures and benchmark levels for reducing acrylamide in food. It provides guidance for food manufacturers on how to lower acrylamide levels in their products. Read the regulation here <https://eur-lex.europa.eu/eli/reg/2017/2158/oj/eng>

With this in mind, we propose a five-year strategic agenda to reduce acrylamide across the entire cereal value chain. This strategy will integrate research on supply chain optimisation, economic impact, and consumer behaviour to support healthier, safer, and more sustainable food systems.

## 2. Exposure Data and Risk Evaluation

To quantify public health relevance, weekly/monthly exposure tables should be constructed using consumption data and acrylamide levels. Priority foods include breakfast cereals (~380 ppb), coffee (>200 ppb), baby foods (BML = 40 µg/kg), and infant biscuits (BML = 150 µg/kg). Additional food items should be included in the Benchmark Levels, **such as beetroot crisps, Bombay mix, powdered soups, fried vegetables, fried peppers, triple-fried potatoes, lentil crisps, Indian fried snacks, breadsticks, pretzels, and similar products.**

### EU Benchmark Levels (Regulation 2017/2158)

Food Category	Benchmark Level (µg/kg)
French fries (fresh potatoes)	500
Potato crisps (from dough)	750
Bread	50
Breakfast cereals	150–400
Fine bakery wares (general)	350
Biscuits/rusks for infants	150
Baby food	40
Roast coffee	400
Instant coffee	850
Coffee substitutes	400



## 4. Summary: Acrylamide Toxicological Risk Assessment

**EFSA Risk Assessment:** The European Food Safety Authority (EFSA) concluded in 2015 (and reaffirmed in 2022) that dietary acrylamide exposure may increase cancer risk across all age groups.

### 4.1 Risk Assessment Process:

**Hazard Identification:** Acrylamide is genotoxic and carcinogenic, affecting DNA and causing tumours in animals.

**Exposure Quantification:** Acrylamide levels were measured in various food groups, and consumption data from over 66,000 individuals were analysed. The most significant contributors to overall dietary exposure were found to be potatoes and miscellaneous cereal products.

Children and adolescents represent the most vulnerable group, with higher acrylamide intake relative to adults due to their lower body weight. As a result, specific recommendations and enforcement measures should be introduced under EU regulations to protect these populations.

**ALARA Principle:** Since acrylamide levels can be reduced to safe MoE thresholds, mitigation aims to keep levels "As Low As Reasonably Achievable." According to Mesias et al. (2022), effective mitigation measures can reduce acrylamide levels by up to 80%.

**Limitations of Animal Data:** Acrylamide's effects in rodents may not fully apply to humans due to differences in metabolism and target tissues (e.g., Harderian glands, absent in humans).

**Human Studies:** Epidemiological data is inconclusive due to limitations in exposure assessment and statistical power. More research is required to validate the toxicological impact of acrylamide on the human body. (Calleman et al., 1994)

**Alternative Approaches:** Use of biomarkers (e.g., DNA adducts) and non-linear dose-response models are being explored but need further validation (Calleman et al., 1994).

**Call for Collaboration:** Continued research and cooperation among academia, industry, and regulators is essential to improve risk assessment and protect public health.

## 5. Strategic Pillars:

### 1. Regulatory Expansion and Immediate Actions

Include high-risk foods not currently covered: olive pizza, chickpea/fava bean snacks, chicory coffee, beetroot crisps, Bombay mix, powdered soups, fried vegetables, fried peppers, triple-fried potatoes, lentil crisps, Indian fried snacks, breadsticks, pretzels, and similar products and vegetable crisps. Evaluate granules and puffed products for infants. Apply ALARA principles and consider Maximum Levels (MLs) for vulnerable groups.

### 2. Strategic Workstream I: Organic Supply Chain Optimisation

This workstream focuses on assessing acrylamide and its precursors within the organic supply chain, which is currently not treated as a distinct category in existing regulations. There is no evidence to suggest that acrylamide levels are higher in organic foods compared to conventional ones, but further research is needed to evaluate these levels accurately. The project will identify organic-compliant fertilisers and biocontrol agents, conduct three-year field trials, and publish validated agronomic

practices. All activities will be aligned with organic certification requirements and food safety standards to ensure regulatory compliance and support sustainable development within the organic sector.

### 3. Strategic Workstream II: Organic Enzyme Innovation

Collaborate with biotech institutions to develop organic-certified asparaginase. Validate under EU organic regulations. Standardise the application in baking and snacks.

### 4. Strategic Workstream III: Pellet Input Control

According to information provided by baby food manufacturers, acrylamide has been detected in pellets. Therefore, it is essential to screen both imported and domestic pellets for acrylamide and other co-contaminants to establish a baseline and mitigate potential residues before they are used in the production of infant and baby food. In addition, pellets intended for baby food production should be subject to **specific regulatory oversight** to ensure safety and compliance. Clear guidance must be provided to suppliers, and detailed input specifications should be established to safeguard the quality and integrity of baby food products.

## 6. Conventional Manufacturer Strategy

### Short-Term

Reducing acrylamide levels in food can be achieved in the short term by targeting its precursors and implementing proper agricultural practices. One key step is to evaluate the sulphur content in the soil and determine whether there is a deficiency. If sulphur levels are low, sulphur-based fertilisers should be applied. Several fertiliser companies have already developed low-acrylamide fertilisers, and this innovation should be expanded across all EU member states. A harmonised fertilisation regime aimed at acrylamide reduction should be recommended for implementation between 2026 and 2027. Additionally, controlling fungal infections and other plant stresses is essential to maintain optimal growing conditions. Monitoring acrylamide precursors, particularly asparagine and sugars such as glucose, fructose, and maltose, is critical. At the processing stage, tiered factory controls should be implemented based on benchmark level (BML) exceedances to ensure consistent mitigation.

### Medium-Term

Internal thresholds for acrylamide levels should be set **well below** the **Benchmark Levels** established by EU regulations. To ensure compliance, regular testing must be carried out by trained personnel. If in-house expertise is unavailable, samples should be sent to accredited external laboratories. All test results should be documented, reviewed, and evaluated in formal reports. Additionally, mitigation logs and consistency reports should be maintained to demonstrate ongoing efforts and the reliability of product quality over time.

### Long-Term Strategy: Genetic Improvement and Supply Chain Integration

To support long-term acrylamide mitigation, it is essential to develop vertically integrated supply chains and breed or select low-asparagine crop varieties. Genetic improvements have shown

promising results, with clear evidence of low-asparagine traits in certain crop backgrounds. To evaluate the effectiveness of these breeding programmes, a coordinated EU-wide initiative should be established, encouraging participation from all member states through EU-funded research and development. This collaborative approach will enable the implementation of new or existing low-asparagine crops across Europe within the next five years, contributing to the goal of providing safe and nutritious food for all.

### Surveillance and Regulatory Refinement for Acrylamide Mitigation

To effectively manage acrylamide exposure, annual surveillance studies should be conducted, focusing on high-risk and high-consumption food categories such as fried potato products, cereal-based snacks, and baked goods. These studies will help identify trends, emerging risks, and areas requiring targeted intervention. Based on surveillance data, Benchmark Levels (BMLs) should be refined to reflect differences in acrylamide formation across specific food subcategories, ensuring more accurate and effective regulation.

Where significant discrepancies in exposure are observed, tailored BMLs/Regulatory Limits will allow for more precise mitigation strategies. To support industry compliance, transition periods of at least six months should be granted for manufacturers to implement necessary changes. Organic producers may require longer grace periods due to the complexity of aligning mitigation measures with organic certification standards and input restrictions.

This approach ensures a balanced regulatory framework that promotes public health while allowing producers sufficient time to adapt. It also encourages innovation in product reformulation, processing techniques, and supply chain management to sustainably reduce acrylamide levels across the food system.

### Conclusions:

1. **Long-term acrylamide mitigation** requires the development of vertically integrated supply chains and the breeding or selection of **low-asparagine crop varieties**.
2. **Genetic improvement programmes** show strong potential, and their effectiveness should be evaluated through a **coordinated, EU-wide initiative** funded by the EU.
3. This coordinated approach could enable the **implementation of low-asparagine crops across Europe within five years**, contributing to safer and more nutritious food.
4. **Annual surveillance studies** are necessary to monitor acrylamide exposure in **high-risk food categories** (e.g., fried potatoes, cereal snacks, baked goods).
5. **Benchmark Levels (BMLs)** should be **refined and tailored** to specific food subcategories for more accurate regulation and targeted mitigation.
6. **Transition periods** should be provided to manufacturers (at least six months, longer for organic producers) to ensure practical compliance with new standards.
7. The proposed strategy balances **public health protection with industry adaptability**, fostering innovation in **reformulation, processing, and supply chain management** for sustainable acrylamide reduction.

## 7. Additional research activities and presentations over 2025

Special issue paper in preparation.

### Legal Disclaimer

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

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.

Views and opinions expressed are however those of the author only and do not necessarily reflect those of the European Union or of the COST Association. Neither the European Union nor the COST Association can be held responsible for them.

This document and its content are the property of ACRYRED Cost Action. All rights relevant to this document are determined by the applicable laws. Access to this document does not grant any right or license on the document or its contents.

### References

- 1) Calleman, C. J., Wu, Y., He, F., Tian, G., Bergmark, E., Zhang, S., Deng, H., Wang, Y., Crofton, K. M., Fennell, T., & Costa, L. G. (1994). Relationships between biomarkers of exposure and neurological effects in a group of workers exposed to acrylamide. *Toxicology and Applied Pharmacology*. <https://doi.org/10.1006/taap.1994.1127>
- 2) **Quality and Chemical Safety of Wheat Bread Enriched with Untreated, Milled, and *Lactiplantibacillus plantarum* Fermented Red Lentils (*Lens culinaris* L.)** Vytaute Starkute a,b, Elena Bartkiene a,b\*, Ernestas Mockus a, Emilis Radvila b, Daiva Matuzeviciute b, Kamile Balynaite b, Arvydas Bredikis b, Gabriele Ilgunaite b, Akvile Juskaite b, Vaneck Cho b, João Miguel Rocha c, Darius Cernauskas d, Romas Ruibys e, Erika Mozuriene a, Meleksen Akin f, Tanya Curtisg and Dovile Klupsaite