

Innovation and risk in low-moisture ready-to-eat ingredients: identifying knowledge gaps and training needs in the supply chain

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Emma Roe, Paul Hurley, Chloe Crowther, Ellie Richold (University of Southampton)
Alex Hughes, K. Marie McIntyre (Newcastle University)

SUMMARY

In parallel with global population growth, food production is a large-scale industrialised process with lengthy supply chains. These chains provide ingredients for food manufacturers and retailers. Consumers usually either purchase manufactured ready-to-eat (RTE) products, or ingredients to make their own food. When low moisture (LM) ingredients are incorporated into RTE products, they present unique microbial risks, potentially causing foodborne illness.

While there is growing scientific evidence around microbial risks in LM RTE foods, there is a gap in understanding about the human dimensions of LM RTE supply chains – of what people know and what people do. This report outlines key findings of social science research – in-depth expert interviews and site visits to food processing and manufacturing sites - undertaken in 2023-24 in collaboration with industry stakeholders in LM RTE supply chains.



Key findings:

- 1) The RTE category is ill-defined, including in the management and regulation of LM ingredients;
- 2) There are gaps in knowledge and training around microbiological safety in LM RTE ingredients, among food business professionals and in consumers;
- 3) Microbiological safety in LM RTE ingredient supply chains is affected by a broad range of environmental, economic, regulatory and geopolitical factors.

1. INTRODUCTION

RTE is a relatively novel food category that creates new challenges to ensuring that food is safe to eat. RTE foods, like houmous, breakfast cereals, and pasties, are intended for direct human consumption, without needing further cooking or other processing by consumers. This means that the most important control measures to reduce or eliminate microorganisms, or to mitigate microbial growth, should be implemented before food is sold to consumers.

LM ingredients such as dried nuts, spices and pulses have historically been considered to have long shelf lives and to present low food safety risks, usually being processed or cooked before consumption. Although microorganisms cannot grow in LM ingredients, some bacteria survive for long periods within them. Microbiological risk can increase when an ingredient isn't stored or processed correctly, or when it is mixed with wetter ingredients in RTE foods with no consumer-level pathogen-reduction step, like cooking.

Food business operators have a legal risk to manage microbiological risk before an ingredient reaches a consumer. Pathogen reduction and elimination involves a 'kill step' such as heat treatment (including pasteurisation), steam treatment, irradiation, or ethylene oxide (outside of the UK and EU). Such processes can affect the quality (e.g. taste and colour) of particular ingredients, so there is often a tension between quality and safety. Some LM ingredients (such as sesame seeds) have a high fat content that can encapsulate microbes and also make the ingredients incredibly difficult to safely heat.

Outbreaks of foodborne illness threaten not only public health, but also the reputation of brands involved, and the industry has seen instances of this in LM and RTE products including chocolate, sesame, houmous, and peanut butter. There is growing demand in the food industry for better understanding of microbial risks, of the ingredient treatment processes required to efficiently remove pathogens and reduce risks, and of the factors affecting shelf life.

The Food Safety Research Network (FSRN), funded by UK Research and Innovation (UKRI) and the Food Standards Agency (FSA), worked in dialogue with Unilever to identify this research challenge in the specific context of ensuring the safety of LM food materials for RTE foods. The FSRN funded our team to collaborate with industry and regulatory stakeholders and to take a social science approach to the problem. We aimed to evaluate: (i) current understanding of microbial risks in LM RTE ingredient supply chains; (ii) existing approaches for managing risks; (iii) gaps in knowledge and training, and reasons for these.

1. METHODOLOGY

In 2022, the Food and Agriculture Organization (FAO) of the United Nations and World Health Organization (WHO) published a report about the management of food safety risks in LM foods (those with a water activity of 0.85 or below). This provides a comprehensive overview of foodborne illness and risk in LM foods from microbiological, food safety and epidemiological perspectives.

FAO and WHO define and rank the following LM food categories in terms of microbial risk: cereals and grains; dried protein products; spices and dried herbs; nuts and nut products; confections and snacks; dried fruits and vegetables; and seeds. While useful, this ranking does not account for the

foods being sold within RTE products, which often increases their microbial risk. The FSRN and our research team saw an opportunity to build on this work with a social-scientific study examining the human knowledges, behaviours and practices within these supply chains, especially in RTE foods comprising or including LM ingredients.

Our project inception involved two co-design workshops – one online and one in-person - in June 2023 - with industry stakeholders to evaluate real-world challenges and to identify routes of addressing them. The workshops included visual mapping, iterative thinking and discursive exercises to employ stakeholders' experience and networks. Together, we identified topics of concern, research questions and research activities that would help us understand how food safety risks are understood and managed in the context of LM RTE foods.

The outcome of the workshops was a set of case study LM ingredients from key categories identified in the FAO report – houmous (seeds and dried protein), oats (cereals), and turmeric (spices) –, selected to give insights across a range of structure of sector, structure of supply chain, and nature of the food safety risk. Stakeholders in the second, in-person, workshop suggested research sites (for visits) and respondents (for interviews). Focusing on single products enabled us to identify key participants, regulatory mechanisms, technological innovations, and stakeholder interactions along their individual, complex global supply chains.

The research began with a literature review of previously published work in this field. There has been little previous social science work around LM RTE supply chains, risk management and training. Together with findings from the co-design workshops, the literature review informed the development of a set of research questions for interviews and site visits. We undertook expert interviews with 23 people, across a range of roles and stakeholder groups, and visits to five locations, some of which also involved focus group interviews.

Interviewees:

Regulatory Executive and Microbiology Lead, industry membership body
Food Policy Advisor, national trade association
Technical Manager, Production Manager, Hygiene Manager, Operations Manager, Technical Controller, dips manufacturer
Head of Food Safety and Quality, food manufacturer
Group Manager, global spice and seasoning manufacturer
Microbiologist, Hygiene Specialist, industry membership body
Food Safety Supply Manager, national retailer
Senior Scientific Affairs Manager, food safety body
Director, pulse and grain supplier
Microbiology Manager, multinational food company
Technical Manager, Supplier Assurance Manager, Quality Manager, multinational cereals company
Director, ingredient processing company
Trader, pulse and grain supplier
Laboratory Manager, Project Manager, food testing laboratory

Sites:

Cereals processing headquarters and manufacturing facility
Dips manufacturing facility
Baked goods manufacturing facility
Food testing laboratory
Grain and pulse processing facility

We recorded and transcribed interviews and made notes during site visits. Transcripts and notes were anonymised, then coded against a set of themes helping us to identify significant topics, passages and patterns (such repetition or differences) that were important across the cohort of interviewees.

3. KEY FINDINGS

3.1 THE RTE CATEGORY IS ILL-DEFINED, INCLUDING IN THE MANAGEMENT AND REGULATION OF LM INGREDIENTS

We discovered in our research that although the FAO's definition of LM is relatively clear ($aw < 0.85$), and is widely understood, RTE is a less distinct category and includes LM foods (such as raw nuts and seeds) as well as higher moisture chilled goods (such as pasties or houmous) that might incorporate LM ingredients. Interviews with industry stakeholders revealed differing levels of knowledge and understanding about the meaning of RTE, both in terms of product but also interpreting and responding to standards and regulation in this area.

Respondents spoke about the fact that some legislation (such as EU2072/2005, EC178/2002 and EC852/2004) doesn't contain microbiological criteria, and that this is often given by the specifications of corporate customers or by industry bodies (such as the European Spice Association's *Minima* document, 2018, or the Institute of Food Science and Technology's *Handbook of Microbiological Criteria for Foods*, 2020). Other respondents noted that different regulations apply to a foodstuff when it is an ingredient being processed or when it is in a final product for consumption.

Further complexity around regulation was experienced by respondents in managing risk and safety in supply chains where ingredients were passing across multiple national borders or being produced for multiple international markets. Some operations were covered by local guidelines such as UKHSA's 'Guidelines for assessing the microbiological safety of ready-to-eat foods placed on the market' (2024), written after the UK's exit from the EU, and by international guidelines, such as Codex's 'Principles and guidelines for the establishment and application of microbiological criteria related to foods' CAC/GL 21-1997 and 'Principles and guidelines for the conduct of microbiological risk management (MRM)' CAC/GL 63-2007.

3.2 THERE ARE KNOWLEDGE AND TRAINING GAPS AROUND MICROBIOLOGICAL SAFETY IN LM RTE INGREDIENTS, FOR FOOD BUSINESS OPERATORS AND CONSUMERS;

While there are strong commitments to food safety and to regulatory compliance across the sector, it is evident that the scale and structure of different food businesses vary greatly. This has implications for food businesses' capacity to understand, interpret and follow legislation without

internal or external technical and quality management expertise. Some businesses may rely on external validation to support food safety management, and others may have internal capacity to do this themselves but experience tensions between commercial, quality and safety priorities. Some respondents – from larger food businesses and from industry trade bodies - reported concern that up to date knowledge wasn't reaching smaller businesses, who might be working with novel ingredient combinations and less regulated consumer contexts, such as markets.

A lack of clarity in regulation and the pace of growth of the RTE food category means that practices and knowledge around LM RTE ingredients are also sometimes inconsistent. Changes in the UK labour force present challenges around who is trained and *how* they are trained in food management practices, creating limits to 'on the job' knowledge application and decision making. In terms of manufacturing operatives, respondents reported concerns about staff shortages, staff turnover, and language communication problems. In terms of technical expertise, respondents reported challenges recruiting senior microbiologists, particularly after Brexit.

3.3 MICROBIOLOGICAL SAFETY IN LM RTE INGREDIENT SUPPLY CHAINS IS AFFECTED BY A BROAD RANGE OF ENVIRONMENTAL, ECONOMIC, REGULATORY AND GEOPOLITICAL FACTORS

Our research also found concern about the vulnerability of LM RTE supply chains to a range of external factors. Respondents reported experiencing supply chain disruption due to geopolitical instability and conflict – such as in Ukraine and Gaza, breaking ingredient supply and transportation routes such as the Suez canal – as well as climate-related crop yield decreases or failure – including recently cocoa and soya.

Many of our respondents described the importance of trusted suppliers and relationships as being a key component of their food safety risk management. Disruptions such as those mentioned put such relationships under increased stress, or necessitate food businesses sourcing ingredients through less established relationships, in which quality and safety is less assured. Products from multiple sources may be materially mixed, making traceability and testability more difficult.

“So from a regulatory perspective, uh, there aren't any specific microbial standards that say your food must be this standard. And when it comes to talking about ready to eat products, that's where we face a considerable challenge because there is no₂ one guide₂ that says this is the rule.”

Group Manager, global spice and seasoning manufacturer

“he [director of a food corporate] really sees a decline in the food safety knowledge of people that work in the food industry. [...] he can't think of a single person in his organisation, obviously respectfully, that he could have a conversation with food safety on [...] it's a dying art.”

Food Policy Advisor, national trade association

“it's not completely unusual to have a site quality manager who understands and a production manager who says, well, this is the way we've always done it and I've never killed anybody”

Microbiology Manager, multinational food company