EDITORIAL

Review of European circular food systems food safety risks

Lara Wilson

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ABSTRACT

Systems for producing food in Europe have improved greatly in terms of high output, quality, and safety. These production methods are not, however, viable because a sizeable amount of the output is lost or wasted during the supply chain, among other factors. A goal of the European Union is to attain climate neutrality by implementing improved waste management practises and a circular economy. Reducing food waste and losses, as well as reusing or recycling waste products from the manufacturing of food and feed, are all part of this. The sustainability of the European food systems would be considerably enhanced by a circular economy, but (new) food safety risks must be taken into consideration. By-products being reintroduced into the system, new processing steps being employed for recycling, and/or existing dangers building up in the food supply chain due to the reuse of (by-) products can all result in new or poorly understood risks. This analysis discusses the risks to food safety in the circular biobased economy, focusing on the areas of plant, animal, aquaculture, and packaging production. Instead of providing a comprehensive list of all potential risks, circular food production system examples are provided, showing the current and future risks to food safety. There is little current literature on newly emerging risks to food safety in the circular economy. Therefore, further study is required to pinpoint potential threats to food safety, quantify how they accumulate and are distributed throughout the food and feed production systems, and create strategies for their control and mitigation.

INTRODUCTION

European food production systems have improved significantly throughout time in terms of high yields, quality, and safety, as well as cheap production costs [1]. The drawback of these production methods is that they are not the most sustainable; the soil is eroding, a great deal of food is wasted, a great deal of artificial fertilisers, pesticides, and antimicrobials are used, and so is the ammonia emission [2]. The European Union (EU) is a proponent of a more sustainable food production system and has recognised the detrimental effects of our current food production system. The EU outlines its strategy to ensure sustainable food production in its Green Deal: The use of chemical pesticides and synthetic fertilisers should be reduced, and nutrients should be added back into the food system. Food waste is defined as "any item or object which the holder discards or wants to or is obligated to discard" (EU, 2008b). The EU proposed a food waste hierarchy, with the first tier being waste prevention, the second being waste reuse, the third being waste recycling (using it as an ingredient in animal feed, for example), the fourth being waste recovery (using composting to recover nutrients and energy from waste), and the fifth being waste disposal. Safe food is defined as food that has been produced, stored, and processed so that it does not include chemicals or microbes at amounts that can be hazardous to human health when consumed [3]. This definition is found in the General Food Law, Regulation (EC) 178/2002. Therefore, the term "unsafe food" refers to food that has been tainted with potential physical, chemical, or biological dangers that could be harmful to human health [4].In addition, the EU has established a set of guidelines and regulations for food and feed, including: I general rules; (ii) guidelines that specify the highest concentrations of hazards that may be present in food; (iii) guidelines that list prohibited substances; (iv) guidelines for novel foods; and (v) guidelines specific to materials that come into contact with food, like packaging [5].Reusing or recycling waste as part of the transition to a circular biobased economy shouldn't endanger the environment or the health of humans or animals, and food and feed products should adhere to EU regulations protecting human health (EU, 2008b), even though there aren't yet any specific regulations for the use of novel by-products or applications and revisions may be required to meet the sustainability targets [6]. Plant and animal production generate a lot of trash, by-products, and secondary products in addition to the primary products themselves .The buildup of food safety risks already existent in the biomass and their dispersion in the production

Editorial office, Journal of Food and Drug Research. Southampton, UK.

Correspondence: Lara Wilson, Editorial office, Journal of Food and Drug Research, . Southampton, UK.

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system could result from efforts to reduce food waste and reuse byproducts of food and feed production or aquaculture [7]. Additionally, new risks may enter the food system due to, for instance, the repurposing of byproducts that haven't been used before or developing during the processing of these byproducts. The Belgian PCB incident of 1999, in which recycled oil and fat containing transformer oil, a source of PCBs, was included in animal feed, or the Irish incident of 2008, in which recycled mineral oil was used as fuel in direct flame to dry bakery waste used as an ingredient in animal feed, are two examples of recycling or improperly processing byproducts leading to food safety incidents. Another instance is the well-known BSE issue, which was brought on by the inclusion of cattle proteins in cattle feed. The main concern is how to reuse byproducts without allowing chemical and microbiological dangers to build up or allowing diseases to spread when feeding farmed animals swill or other feed containing animal proteins. Data on the numerous potential food safety risks associated with decreasing food waste and reusing byproducts in food production systems are scarce and dispersed throughout the various circular food production methods. Heavy metals halogenated organic compounds, foodborne pathogens, and antibiotic resistance genes were listed as the kinds of chemical and microbiological pollutants that Thakali and MacRae (2021) proposed a first review encompassing (ARGs). A safe circular system could be prevented by a number of contamination paths and risk factors, which have been discovered. This review intends to provide light on new risks associated with European-scale circular food production systems. It addresses a variety of chemical and microbial food safety risks. There are countless ways to generate in a cyclical manner and shut loops. As a result, we did not try to present a thorough list of all potential food safety risks. Instead, examples of enhanced circularity in the food system with associated, potentially emergent risks are shown. Although this assessment focused on risks within the context of European law, information on the existence and buildup of risks due to the reuse of byproducts is relevant worldwide. he four production domains of plant, animal, aquaculture, and packaging production are separated out in this review. A few pertinent recycled inputs and outputs from a circular economy are discussed for each subject. The inputs of compost, biosolids, and manure-based waste soil additives, irrigation water, and soil are discussed for the field of plant production. Plant byproducts are taken into account as outputs. Inputs for the area of animal production are covered, including feed materials made from plants, feed materials containing animal proteins, and insects. The outputs taken into consideration include animal byproducts like slaughter waste. Only a few outputs, primarily used as fish or farm animal feed, are mentioned for the aquaculture sector because many inputs have already been covered in prior sections: Seaweed and fish byproducts, such as fish meal, mussel meal, and other fish byproducts. Additionally, the output of water is considered. The topic of packaging is covered in the final section. Instead than being organised by inputs and outputs, the section is organised by type of packing material. Sludge or biosolids can be removed from municipal, commercial, and combined waste water systems, and the resulting digestates and compost can be added to top soil to improve plant growth. Sewage sludge and waste water contain a variety of organic pollutants from both consumer and industrial goods and applications. The loads of more than 2000 compounds in Swedish wastewater were estimated by Gustavsson, Molander, Backhaus, and Kristiansson in 2022. Detergents, surfactants, dyes and pigments, brominated flame retardants (BFRs), and numerous other chemical groups were among the variety of compounds used in their investigation. Many of these could have an impact on how safe agricultural products are, however how much is still unknown. Persistent organic pollutants (POPs) are bound by the organic carbon in biosolids from civil wastewater treatment plants, which may introduce POPs into the food chain. Environmental pollutants known as POPs are those that are persistent in the environment, build up in the food chain, and endanger both human health and the environment. POPs are industrial chemicals like PCBs, dioxins, perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA), short chain chlorinated paraffins (SCCPs), some BFRs, and some medicines. Well-known pesticides like Aldrin, Chlordane, and DDT are examples of POPs. In sewage sludge, Aro et al. (2021) discovered a wide variety of PFAS, including perfluoroalkyl acids (PFCAs), perfluoroalkyl sulfonates (PFSAs), perfluoroalkyl sulfonamides (FOSAAs), and fluorotelomer phosphate mono- and diesters (mono and diPAPs). Herrmann, Maier, Bauer, Bugsel, and Zwiener (2021) In Germany, a substantial number of PFAS were examined in agricultural soils that had been contaminated by the application of paper manufacturing sludge. Additionally, the presence of heavy metals in biosolids, such as cadmium (Cd) and lead (Pb), has been identified as posing significant risks . Due to the reduction in the organic content of the residual material and the persistence of heavy metals, their concentration tends to rise during the chemical and physical treatment of the biosolids. Another major obstacle to the reuse of this waste stream is microbial dangers. The pathogenic microorganisms Campylobacter jejuni are frequently found in biosolids. *E. coli, L. monocytogenes, Salmonella spp.*, and *parasites like Cryptosporidium spp.* are frequently found in biosolids. Furthermore, ARGs can be found in biosolids. Although it is believed that biosolids have lower quantities of ARGs than manure does, applying either waste stream can raise ARG concentrations above background levels following application. The most dangerous pathogens in biosolids are expected to be viral infectious pathogens, which appear to be persistent in biosolids. Adenovirus, enterovirus, and norovirus are among the viral pathogens frequently found in biosolids.

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