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Selection of critical factors for identifying emerging food safety risks in dynamic food production chains

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ABSTRACT

A pro-active emerging risk identification system starts with the selection of critical factors related to the occurrence of emerging hazards. This paper describes a method to derive the most important factors in dynamic production chains starting from a gross list of critical factors. The method comprised the semi-quantitative evaluation of the critical factors for a relatively novel product on the Dutch market and a related traditional product. This method was tested in an expert study with three case studies. The use of group discussion followed by individual ranking in an expert study proved to be a powerful tool in identifying the most important factors for each case. Human behaviour (either producers' behaviour or human knowledge) was the most important factor for all three cases. The expert study showed that further generalization of critical factors based on product characteristics may be possible.

1. Introduction

Food safety has ameliorated over the years due to the application of Hazard Analysis Critical Control Points (HACCP) systems and the development of risk assessments (RA). HACCP is a systematic approach to the identification, evaluation and control of those steps in food manufacturing that are critical to product safety. The basic objective of the HACCP concept is assuring the production of safe food products by prevention instead of quality inspection (Luning, Marcelis, & Jongen, 2002). HACCP is a system applied to identify known food safety hazards, and is currently applied per stage in the production supply chain instead of the total production chain. Food safety RA comprises the scientific evaluation of known or potential adverse health effects resulting from human exposure to specific food borne hazards (Codex, 1999). It typically uses data on the particular hazard and production chain under consideration, and modelling to estimate the final likelihood of harm due to human exposure. Both HACCP and RA focus on known hazards and make use of historical data related to the particular hazard(s) as well as to the particular chain of interest. Risk managers and assessors need to get access to all available data on food safety hazards as soon as possible. For this purpose, there are various warning systems for notification on the likelihood of a hazard. Examples are the EU Rapid Alert System on Food and Feed (RASFF, http://ec.europa.eu/food/food/rapidalert/index_en.htm), the WHO-Global Outbreak Alert and Response Network (http://www.who.int/csr/outbreaknetwork/en/) and the Global Public Health Intelligence Network (GPHIN) in Canada (http://www.phac-aspc.gc.ca/media/nr-rp/2004/2004_gphin-rmispbk_e.html) (Marvin et al., 2009). Such warning systems address known, well-characterized food and feed safety hazards (Marvin et al., 2009; VWA, 2006).

In order to identify and prevent emerging hazards leading to food safety risks, it is necessary to move towards a more pro-active system for identification of emerging food and feed related risks (Marvin et al., 2009). An emerging risk (ER) is defined as a risk resulting from a newly identified hazard to which a significant exposure may occur, or from an unexpected new or increased significant exposure and/or susceptibility to a known hazard (EFSA, 2007). ER may be directly linked to the food production chain or indirectly connected to it (Marvin et al., 2009). Therefore, in order to identify emerging risks in an early stage, an holistic approach is proposed (VWA, 2005). This approach implies that emergence of a risk can be the result from factors inside the production chain (endogenous) or outside the chain (exogenous). In addition, emergence of hazards related to risks is usually a result of a particular change inside or outside the production chain. A pro-active system for the identification of emerging food safety risks should, therefore, preferable be based on (endogenous and exogenous) factors characterizing the dynamics of a food production system. Endogenous factors (associated with changes within the production chain) may be related to technological innovations, their implementation driven from production perspectives. Exogenous

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factors (associated with changes outside the production chain) may include for example economic changes, climate change, international trade and changes in human behaviour. These exogenous factors are related to influential sectors as described in the EMRISK and PERI-APT project (VWA, 2005, 2006).

Once critical factors are identified, signals can be established that indicate (directly or indirectly) the occurrence of an emerging hazard; the so-called indicators. An example of a critical factor is climate change with temperature and rainfall as indicators (Van der Fels-Klerx, Kandhai, & Booij, 2008; VWA, 2005). These indicators form the key elements of an ER identification system. For these key indicators, information sources (data and expertise) and critical limits should be determined. When the limit of one or more indicators is exceeded, required actions can be taken in an early stage to prevent food safety problems occurring as a result of substantial changes in novel and/or dynamic production chains (VWA, 2006).

Several studies have been performed on the identification of critical factors to be used in an ER identification system. In these studies, a retrospective approach has been applied in which cases from the past were analysed in order to select the most important critical factors. Examples of cases studied are Avian Influenza (AI), Severe Acute Respiratory Syndrome (SARS), acrylamide, trans fatty acids, dioxins and Bovine Spongiform Encephalopathy (BSE) (Hagenaars et al., 2006; VWA, 2005, 2006). Although these studies elaborated on critical factors, they are restricted since they are event and/or hazard driven and, consequently, the results may be case-sensitive. As such, it is unclear whether these findings are also applicable to identify emerging food safety risks in dynamic production chains. The aim of this research is to explore the feasibility of a systematic approach to identify the most important critical factors related to changes in production chains that may lead to food safety problems.

2. Materials and methods

The method developed, to identify critical factors for emerging risks related to dynamics in production chains, was based on a two-stage approach:

1. Identification of the most important critical factors indicating changes in production chains.
2. Linking the selected factors to the occurrence of emerging food safety risks.

For this purpose, a comprehensive list of potential critical factors was established based on a literature review (Section 2.1) and their importance evaluated for three cases. The cases consisted of a traditional product versus a relatively novel product on the

Table 1
Critical factors for pasteurized milk and Valess (a vegetarian product prepared from algae and curdled milk). X = expert; G = group consensus workshop.

	Pasteurized milk 2006 compared to 2000										Valess compared to pasteurized milk in 2000									
	Identified change[a]					Related food safety risk[b]					Identified change[a]					Related food safety risk[b]				
	−2	−1	0	+1	+2	−2	−1	0	+1	+2	−2	−1	0	+1	+2	−2	−1	0	+1	+2
Endogenous factors																				
1. Number of chain participants			XG					XG						G	XG				XG	
2. Number of processing steps			G	X G			XG							G	XG				XG	
3. Number of raw materials			XG					XG							XG				XG	
4. Number of suppliers of raw materials	G	G		X			G	G	X			G	G		X			G	X	
5. Logistics (distribution of food over the chain)				XG			G		X						XG				XG	G
6. Destination of produce (niche, local, export)			G	X				XG					G	X				XG		
7. Firm size				XG	G		GX	G						XG	G				XG	G
8. Information exchange				XG			XG							XG			XG			
9. Contractual agreements (quality, safety)				XG			XG	G						XG			XG	G		
10. Integration and cooperation				XG			XG	G						XG			XG	G		
Producers' behaviour:																				
11. Food safety awareness				XG			XG	G					XG				XG	G		
12. Probability of detection				XG			XG						XG				XG			
13. Severity of sanction				XG			XG						XG				XG			
Technological innovation:																				
14. Product			XG	XG			XG	XG							XG		X		XG	
15. Package			XG	G				XG						X	G			G	X	
16. Transport (e.g. temperature)			XG	G			G	XG					XG	XG				XG	XG	
17. Process				XG			XG								XG				XG	G
18. Genetically modified raw materials[c]			XG					XG					XG					XG		
Exogenous factors																				
19. Origin of raw materials, global sourcing			XG					XG					XG	XG				XG	XG	G
20. Legal requirements			G	XG	G		G	XG					G	XG	G		G	XG		
21. Impact climate change			XG	G				XG	G				XG	G				XG	G	
22. Economic status			G	X				G	X					XG	G			G	X	
Consumer factors																				
23. Demand (quantity)		X	G					XG					G	X				XG		
24. Assortment				XG				XG						XG				XG		
Demand with respect to:																				
25. Environment			XG	G				XG					XG					XG		
26. Animal welfare			X	G	G			XG					X	G	G			XG		
27. Sensory-quality			XG					XG					XG					XG		
28. Convenience			XG	XG				XG					X	G	G			XG		
29. Health			XG	G				XG					G	XG				XG		

[a] Much less (−2), less (−1), no change (0), more (+1) much more (+2).
[b] Substantially declined food safety risk (−2), declined risk (−1), no impact (0), increased risk (+1) substantially increased risk (+2).
[c] Excluding animal feed.