Quality Assurance and Safety of Crops & Foods

ICC MoniQA

Quality Assurance and Safety of Crops & Foods 2010, **2**, 173–181

REVIEW

Rapid test methods: a versatile tool to assist food-safety management

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Keywords
food safety; HACCP; analysis; quality assurance.

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Received 11 June 2010; Revised 10 September 2010; Accepted 2 October 2010

doi:10.1111/j.1757-837X.2010.00080.x

Abstract

Introduction Rapid test methods are increasingly being promoted as tools for food companies to validate and/or verify the efficacy of their food-safety management systems. However, little is known about their take-up by the industry nor on what industry's current and future needs are. *Objectives* In order to gain further information a questionnaire-based survey was conducted in 17 countries (11 European Union members and 6 non-European Union members). The survey was designed to gain insight into routine analytical regimes operated by food industries and the role played in them by the use of rapid test methods. *Methods* Over 2600 questionnaires were circulated to companies covering the whole food chain and 661 replies (about 25%) were received. *Results* At a strategic level, the survey revealed that raw materials and final products are the most routinely analyzed samples, and that the major analytes tested for concerned (in descending order) microbiological contaminants, heavy metals, pesticides, foreign bodies, mycotoxins and allergens. With regard to the use of rapid test methods, 66% of the respondents use them, while, almost all respondents stated their interest for extending the range of tests performed. In terms of future needs, rapid tests for microbiological analysis was emphasized by most respondents, while food allergens and mycotoxins-related test kits were also of high importance. *Conclusions* The results obtained indicate that the food industries currently use or are well prepared for the implementation of new rapid methods of analysis.

Lebesi D, Dimakou C, Alldrick AJ, Oreopoulou V (2010). Rapid test methods: a versatile tool to assist food-safety management. *Quality Assurance and Safety of Crops & Foods*, **2**, 173–181.

Introduction

Modern food-safety management standards operate on the precepts of quality assurance, e.g. Hazard Analysis Critical Control Point (HACCP, Codex Alimentarius Commission, 2003). A key element of such systems is for food businesses to verify the effectiveness of such systems on both current and historical bases. An important tool in the verification process is testing for the presence of analytes of food safety significance. In a number of jurisdictions [e.g. European Union (EU)] there are statutory requirements not only for food businesses to operate in accordance with HACCP principles but also that food businesses should conduct such analyses as necessary and at an appropriate frequency (European Parliament & Council, 2004).

Laboratory analysis is an important tool in both validation and verification and typically employs techniques such as, chromatography and spectrophotometry. Most of these methods are unsuitable for direct application in food businesses because they are often, time consuming and needing well-trained operators as well as specialist equipment and consequently expensive. As a result, a view has

been expressed that food and drink industries need rapid and affordable test methods not only to replace existing ones but also to test for analytes that have not been monitored previously (Wagner & Guilbault, 1994). The availability of fast, reliable and simple to use detecting tools for food products is considered to be a target both for safeguarding of customer's health and production improvement (Tang *et al*., 2009).

One of the objectives of the EU network of excellence project *MoniQA* ('Towards harmonization of analytical methods for monitoring food quality and safety in the food supply chain;' http://www.moniqa.org) is to evaluate and optimize the use of rapid test methods in the area of food safety. As part of this exercise we have sought to gain further insight into industry attitudes to food-safety analysis in general; the current uptake of rapid-test methods by the industry and their future needs in this area. This paper discusses the results. This was achieved as part of a questionnaire-based survey concerning the application of analytical and information technologies to food-safety management. It was undertaken in 11 EU Member States and six significant food-trading partner countries.

Materials and methods

Questionnaire structure

The questionnaire used in the survey (available at http://www.moniqa.org) was entitled 'use of laboratory analysis and information communication technology in food-safety management. It was of a "check-box" design to enable respondents to answer questions by simply checking against statements with which they agreed with'. This paper is concerned with the food analysis aspects of the survey, which focused on two principal themes:

- Analytes currently being tested for (either in house or in an external laboratory) and future needs.
- Analytes specifically being tested for on-site using rapid test kits and future needs.

In addition to questions concerned with food analyses, details were also sought concerning the principal business of the respondent, its size (using the criteria for small medium or large enterprises; Commission of the European Communities, 2003) and whether or not the business was certified to a particular food safety standard (e.g. ISO 22000:2005). The questionnaire was initially drafted in English and reviewed by a MoniQA supervisory group to minimize the risk of ambiguity. Vocabulary and sentence structure were kept simple to facilitate ease of translation into the native language of the participating country. The English version of the document was sent to the relevant MoniQA partner in the country participating in the survey, where it was translated into the native language for subsequent distribution.

Survey procedure

Seventeen countries participated in the survey, out of which 11 were Member States of the EU (Belgium, Bulgaria, Finland, France, Germany, Greece, Hungary, Italy, Poland, Spain and United Kingdom) and six non-EU members (Albania, China, New Zealand, Norway, Turkey and Vietnam). More than 2600 questionnaires were circulated and replies collected over a 6-weeks period from companies covering the whole food chain, e.g. raw material and ingredient suppliers, food processing companies, retailers and catering companies. After preliminary assessment, data were categorized and analyzed on an aggregate basis, according to the food product sector, and the economic status/size of the companies to enable better interpretation of the results.

Results and discussion

Description of respondent base

A total of 661 replies were received and an analysis on a per-country basis is shown in Table 1. The number of responses

Table 1 Profile of respondents by country (economic size)

		SMEs			Non-SMEs
Country	Total	Micro	Small	Medium	Other
Albania	6		3	1	2
Belgium	50	17	18	12	3
Bulgaria	50	12	22	12	4
China	47	3	14	19	11
Finland	16	1	10	2	3
France	12	2	5	5	
Germany	34	2	4	11	17
Greece	41	2	11	14	14
Hungary	30	2	4	4	20
Italy	116	29	47	27	13
New Zealand	5			2	3
Norway	47	2	15	3	27
Poland	16	2	2	10	2
Spain	29	4	8	5	12
Turkey	48	1	7	22	18
United Kingdom	73	2	9	24	38
Vietnam	41	1	4	6	30
Sum	661	82	183	179	217

received from EU Member States was 467 (71%), while 194 (29%) questionnaires were received from non-EU countries. Profiles of the respondents from each country on the basis of business size and industrial sector are shown in Tables 1 and 2, respectively. In terms of business size, 444 (67%) were classified as SMEs (i.e. employing < 250 individuals and having a turnover of below 50 million euros; Commission of the European Communities, 2003). Figure 1 shows the aggregate distribution of food businesses in terms of the product types. Although most of the respondents were concerned with a single type of product, a number ($n = 103$) were involved in more than one of the categories listed in the questionnaire. In terms of identifiable product categories the largest group of food businesses responding were concerned with meat and fish ($n = 101$), followed by beverage companies ($n = 67$), dairy companies ($n = 65$) and

Table 2 Profile of respondents by country (industrial sector)

	Food industry grouping									
Country	Ingredients	Bakery and breakfast cereals	Dairy	Meat/ fish	Oils and fats	Fruit/ vegetables	Ready to eat	Beverages	Other	Multiple products
Albania		1						3	1	1
Belgium	4	5	3	6	3	3	4	4	12	6
Bulgaria	4	4	4	15	1	1	2	3	4	12
China	7	0	6	1	0	1	1	8	23	0
Finland	0	2	5	2	1	1	1	1	1	2
France	2	1	1	2	0	1	0	1	2	2
Germany	4	2	1	1	3	3	3	1	8	8
Greece	0	3	7	4	2	4	3	1	5	12
Hungary	0	2	2	1	0	5	0	1	7	12
Italy	5	13	8	26	6	8	2	10	15	23
New Zealand				4						1
Norway	0	0	3	17	0	0	0	0	15	12
Poland	0	2	1	1	0	0	0	2	10	0
Spain	2	3	0	7	1	2	2	1	6	5
Turkey	1	2	7	1	3	11	1	1	14	7
United Kingdom	13	7	10	3	12	4	3	21	0	0
Vietnam	0	0	7	10	0	10	0	9	5	0
Sum	42	47	65	101	32	54	22	67	128	103

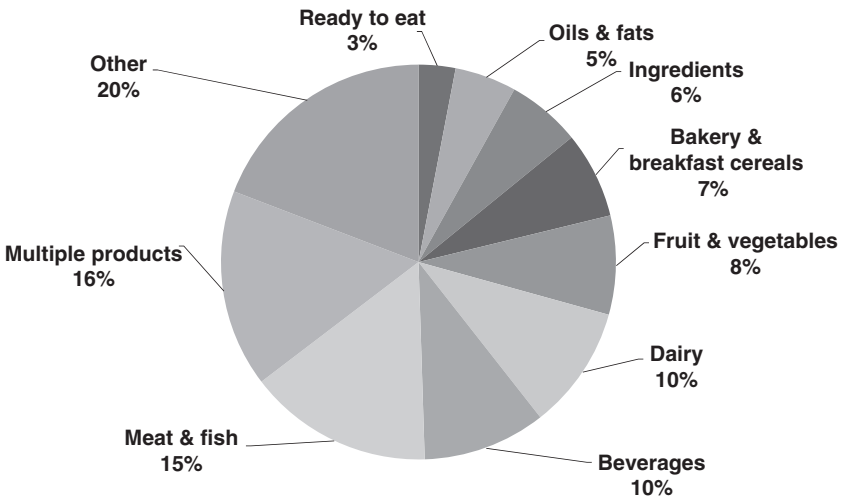

Figure 1 Aggregate distribution of respondents by industrial sector.

fruit/vegetable companies ($n = 54$). Most ($n = 581$) of the respondents reported that they were certified to an externally accredited food-safety management standard. The two most common being ISO22000:2005 ($n = 225$) and the BRC Global Food Safety Standard ($n = 212$). All of the respondents advised that they routinely submitted samples for laboratory analysis. In terms of the laboratory facilities used, 56 (9%) respondents reported that only on-site analyses were performed while 232 (35%) only used an external laboratory. Most respondents ($n = 373$; 56%) used both internal and external facilities. Analyzing by business size/economic status, SMEs tended to outsource all of their analyses to external laboratories (37% versus 18% for non-SME's), while larger companies tended to use both internal and external laboratory resources (64% versus 45% for SME's).

Samples and contaminants analyzed on scheduled basis as part of the company's food-safety management program

Respondents were asked to identify which samples, i.e. raw material, semi-processed products, final products, environmental samples (hygiene related) or 'other' were routinely sent for laboratory analysis. They were also asked whether or not they were operating foreign body detection equipment. In terms of the type of sample submitted for analysis 624 (94%) respondents stated that they submitted final products for analysis, compared with 592 (90%) for raw materials, 459 (69%) for environmental samples and 388 (59%) for intermediate products. No difference was observed between SMEs and non-SMEs.

In terms of groups of analytes tested for (Figure 2), the most common was microbiological contaminants (90%) followed by heavy metals (49%), pesticides (48%), mycotoxins (41%) and allergens (25%). A substantial number indicated that they tested for the presence of foreign bodies, however, this mainly reflected the routine food industry use of foreign body detectors. Interestingly when looking at the five highest ranking analytes tested for on a food business sector basis (Table 3) – although their relative ranking changed to some degree between sector – four groups of analytes (microbiological, heavy metals, pesticides and foreign bodies) were common across the board, with microbiological analyses ranking first in all sectors with the exception of oils and fats. Mycotoxins ranked as one of the top five types of analytes tested for, in all but the meat and fish sector. Allergen testing featured in the top five of the meat and fish as well as the ready to eat foods sectors, while organic environmental contaminants ranked joint fifth in the meat and fish sector.

Similar results were obtained when the comparison was made on the basis of business size (SME versus non-SME) albeit with slightly different proportions (data not shown).

Current use, efficacy and future needs of rapid methods

Respondents who indicated that they performed some or all analyses on site ($n = 429$, 65%) were asked further questions

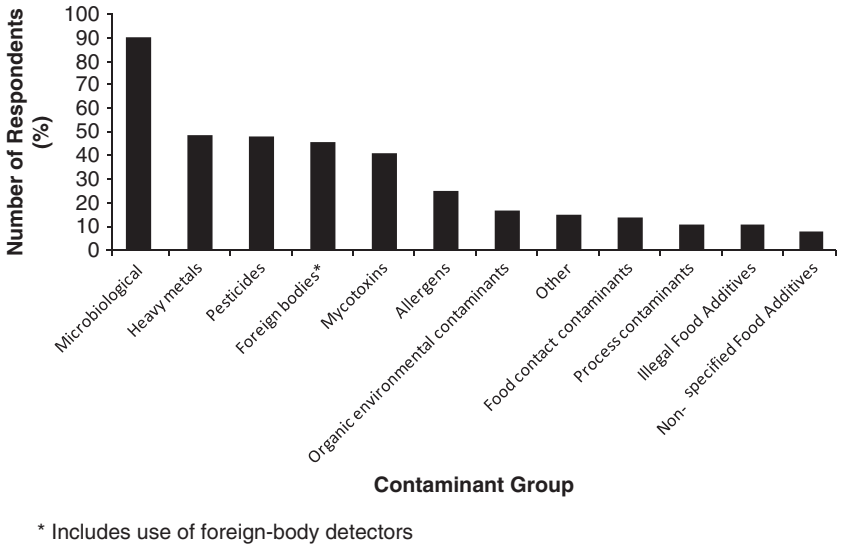

Figure 2 Food contaminants routinely submitted for laboratory analysis (aggregate data by analyte group).

Table 3 Laboratory analyses: ranking by industry sector of top analytes tested for (percentages shown in parentheses)

Ingredients (%) (*n* = 42)	Bakery and breakfast cereals (%) (*n* = 47)	Dairy (%) (*n* = 65)	Meat/fish (%) (*n* = 101)	Oils and fats (%) (*n* = 32)	Fruit/vegetables (%) (*n* = 54)	Ready to eat (%) (*n* = 22)	Beverages (%) (*n* = 67)	Other (%) (*n* = 128)	Multiple products (%) (*n* = 103)
Microbiological (81)	Microbiological (100)	Microbiological (88)	Microbiological (99)	Pesticides (87)	Microbiological (94)	Microbiological (100)	Microbiological (80)	Microbiological (83)	Microbiological (100)
Heavy metals (60)	Mycotoxins (88)	Mycotoxins (46)	Heavy metals (34)	Heavy metals (78)	Pesticides (85)	Pesticides (44)	Pesticides (57)	Foreign bodies (53)	Heavy metals (52)
Mycotoxins (58)	Heavy metals (70)	Pesticides (38)	Foreign bodies (32)	Microbiological (67)	Heavy metals (72)	Allergens (44)	Heavy metals (51)	Mycotoxins (45)	Pesticides (51)
Pesticides (56)	Pesticides (66)	Foreign bodies (38)	Pesticides (21)	Mycotoxins (56)	Foreign bodies (62)	Foreign bodies (44)	Mycotoxins (37)	Heavy metals (40)	Mycotoxins (50)
Foreign Bodies (52)	Foreign bodies (64)	Heavy metals (32)	Allergens (21)	Foreign bodies (33)	Mycotoxins (33)	Heavy metals (38)	Foreign bodies (34)	Pesticides (31)	Foreign bodies (49)
			Organic environmental contaminants (21)						

around the use of rapid test methods. These questions centered around two points:

- Were rapid-test methods already being used and if so for what (use)?
- In the opinion of the respondent had the use of rapid test kits contributed to an improvement in food-safety management?

In addition, all respondents were asked to identify which analytes they would wish to see new rapid tests developed for – (need), regardless if they performed analyses on site or not.

Of the 429 respondents who performed some or all analyses on site, 285 (66%) advised they were using some form of rapid method as part of their routine analyses. Data in terms of 'use' and 'need' for different analytes are shown in Figure 3. Consideration of Figure 3 indicates that the most commonly used rapid test methods were for microbiological analytes followed by mycotoxins and allergens while the least used were for pesticides and food additives. In terms of future needs, most respondents ranked microbiological-related test kits as their first priority followed by allergens, mycotoxins, pesticide and heavy-metals-related analytes. As in the case of laboratory-tested analytes, the use of rapid methods was more dependent on the type of food processed rather than business size.

Regarding the nine food product categories distinguished in the questionnaire, rapid methods were used and needed in all sectors. The ranking of used and needed rapid methods differed among the sectors, as shown in Figure 4. The only type of rapid method used and needed in all sectors was for microbiological analytes. Also, mycotoxin-related rapid methods were needed in all sectors and used in eight out of the nine sectors (oil and fat companies excluded). Considering current use, microbiological-related rapid methods ranked first in all sectors except for ingredient companies and for bakery companies. Mycotoxin-related test kits were mainly used by ingredient and bakery companies. Allergen-related rapid test kits were widely used by ingredient companies and ready to eat food companies, while pesticide and heavy-metal-related test kits were mostly used by oil and fat companies and ready to eat food companies. Process and food contact contaminants-related rapid test kits were only used by a limited number of respondents from dairy, meat/fish, fruit/vegetable and ready to eat food companies.

In general, all sectors stated as needed rapid test kits for most of the analytes listed in the questionnaire (Figure 4). Microbiological-related rapid test kits were the ones referred

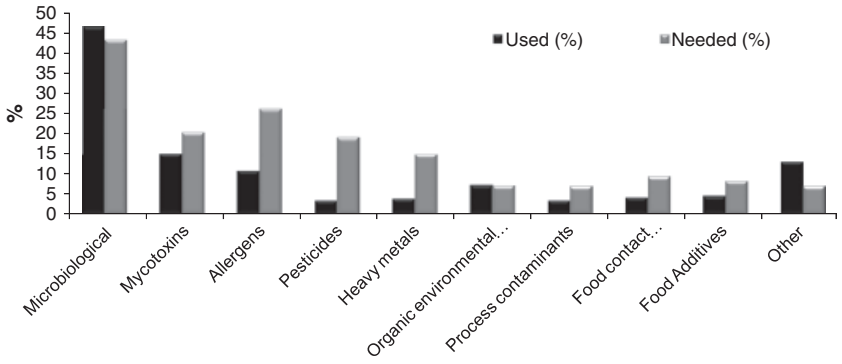

Figure 3 Rapid test methods used and needed (%). Percentages of used are calculated on the basis of the combined number of respondents who indicated that they undertook some or all of their analyses on site, while that of needed on all respondents.

to as the most needed by all sectors except fruit/vegetable companies. Mycotoxin-related rapid test kits were mostly needed by ingredient and bakery and breakfast cereal companies while allergen-related test kits were mostly stated as needed by ingredient and meat/fish companies. Pesticides and heavy-metals-related rapid methods were stated as needed by a considerable percentage of ingredient and fruit/vegetable companies. The analytes for which tests were least referred to as needed were process contaminants, organic environmental contaminants, food contact contaminants, food additives and 'other' rapid test kits.

When asked about the contribution made by rapid methods to their food-safety management systems, 62% of the respondents considered that their introduction had contributed to improved food-safety management, 4% considered that they had not made any improvement while 12% did not know. The remainder did not answer the relevant question. Similar results were obtained when the analysis was performed on the basis of business size or product sector.

Discussion

From a philosophical point of view, the use of rapid test methods by food businesses would appear to be useful adjunct to more efficient food-safety management. A view held by 62% of the respondents who were actually using them.

The survey was not stratified. In other words the number of responses for different business sectors, countries or business size are not necessary proportional to their relative numbers. It is for this reason that only broad qualitative comparisons have been made. Nevertheless, the survey provides a useful insight into the food-industry's use of food analysis within a number of EU Member States, as well as some of its significant food-trading partners. The data obtained indicates that the use of rapid test methods has penetrated large areas of the food industry and that demand for further methods continues. Demand appears to reflect two factors:

- The ever-present threat of microbial contamination.
- An increasing awareness of food-safety issues relating to mycotoxins and food allergens.

The challenges to food-safety management in terms of microbiological hazards can be seen by consideration of epidemiological data for the United Kingdom concerning the major food poisoning organisms (Health Protection Agency, 2010). During the period 2000–2009, while the numbers of reported *Salmonella* spp. infections has dropped progressively, those relating to *Campylobacter* spp., have now started to rise again after falling between 2000 and 2004, while *Listeria monocytogenes* rose through to 2004 and have now apparently reached a plateau. Food poisoning reflects events in the food chain and/or the home; nevertheless the further development of cost-effective rapid test kits to validate and verify current and modified food-safety management systems for these organisms would make a significant contribution to public health.

The second key area of need relates to chemical contaminants and in particular food allergy and mycotoxins. The 'demand' for rapid test methods which address these two groups of analytes reflects either an increased prevalence of a clinical condition as evidenced in the case of food allergy (discussed by Kerbach *et al*., 2009) or a progressively more stringent regulatory environment as in the case of mycotoxins (discussed by Alldrick *et al*., 2009). In both cases control of the hazards presented by these agents is primarily effected through pre-requisite programs. Pre-requisite programs are those components of Good Manufacturing Practice that 'provide the basic environmental and operating conditions

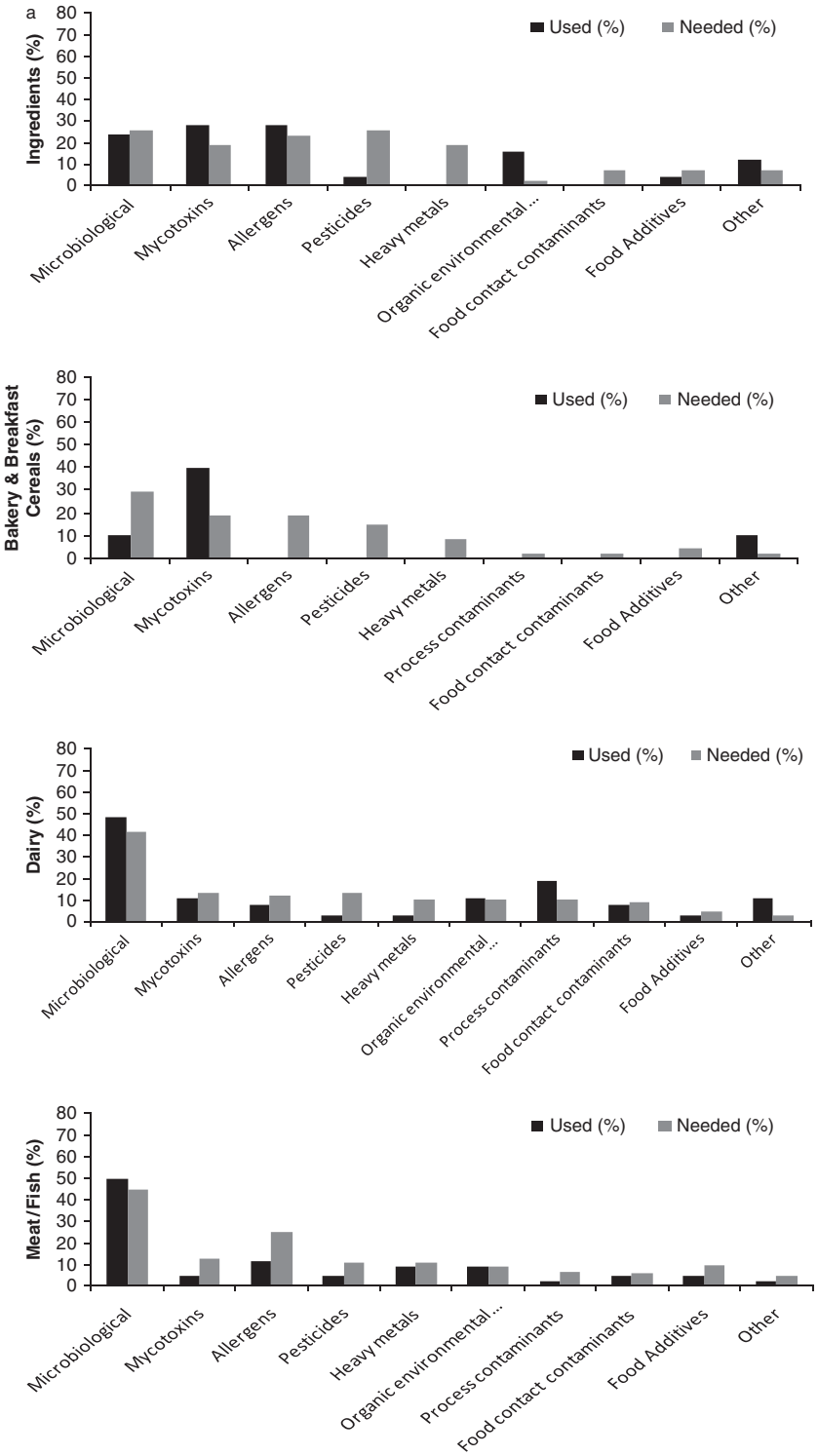

Figure 4 Rapid methods used and needed in the different food product sectors (%). Percentages of used are calculated on the basis of the combined number of respondents who indicated that they undertook some or all of their analyses on site, while that of needed on all respondents.

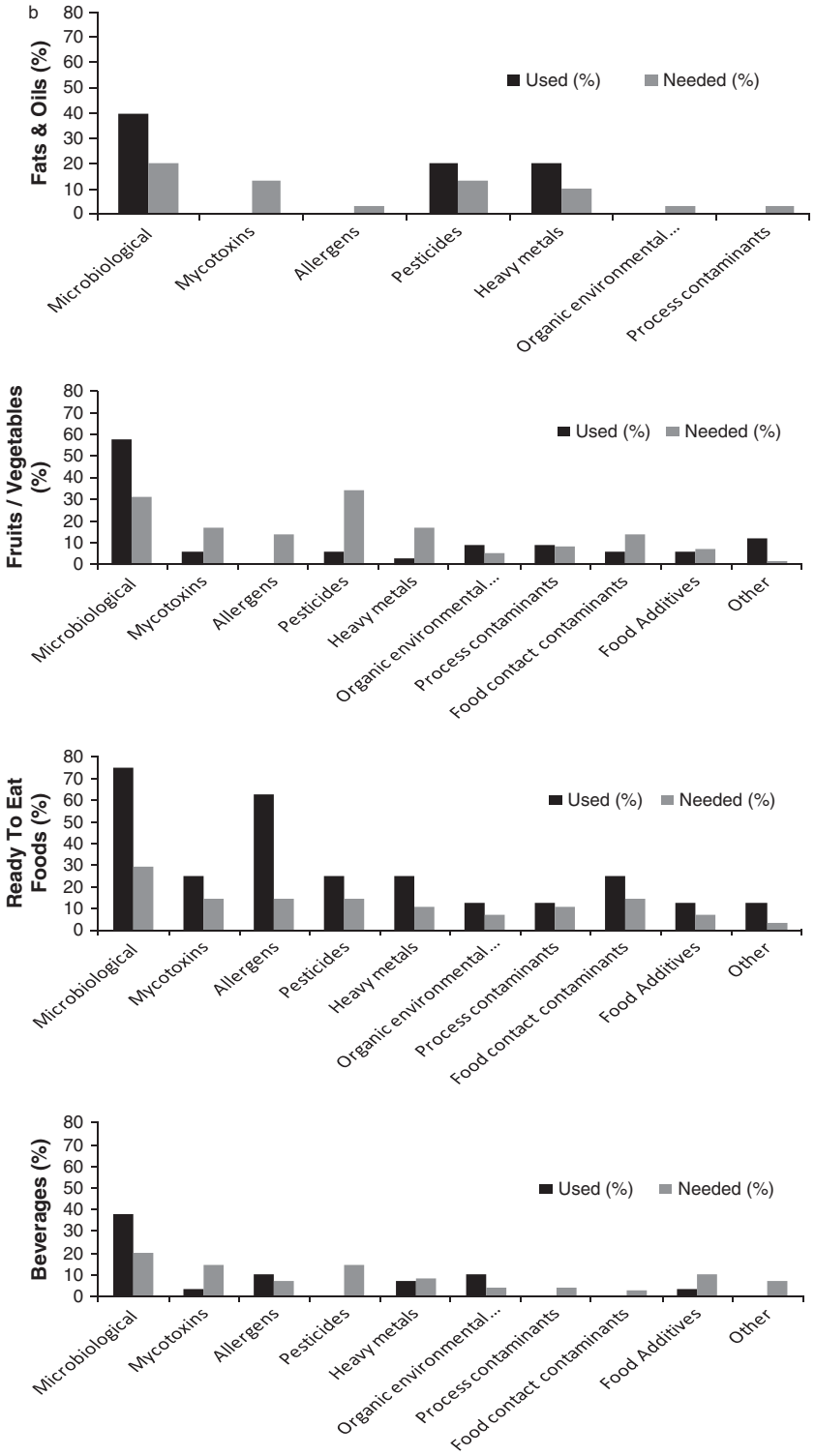

Figure 4 Continued.

in a food business that are necessary for the production of safe and wholesome food' (Gaze, 2009). Thus in the case of food allergens, among other areas, rapid test methods provide a valuable resource for validating and verifying the effectiveness of sanitation practices to minimize the risk of cross-contact contamination. Similarly, rapid test kits for

mycotoxins provide purchasers the means to verify the effectiveness of supplier quality assurance programs to ensure that vendors supply materials that comply with specification.

Acknowledgments

This work was undertaken as part of The MoniQA Network of Excellence, which is funded by the European Commission (contract no. FOOD-CT-2006-36337) within the Sixth Framework Programme Topic T5.4.5.1: Quality and safety control strategies for food (NOE). The authors appreciate the contribution of the following MoniQA partners: Hanna-Leena Alakomi, Ayse Bakan, Aihnoa Bilbao, Zsuzsanna Bugyi, Cathrine Finne Kure, Velitchka Gotcheva, Sandra Kerbach, Susan Paulin, Xiaofang Pei, Maddalena Ragona, Christelle Robert, Kim Ahn To and Halina Tureskja.

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