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Abstract

Food safety and quality is a major political topic due to numbers of deaths and hospitalizations all over the world due to food contamination, due to the increasing concern of consumers with public health related issues, due to increasing complexity of internationalization of food chains, along with the stronger sanitary standards set for international trade. Many constraints can explain the delays in the establishment of measures to prevent and control of food contaminants throughout the food value chains. Therefore, the availability of simplified tools that can be used to mitigate food safety hazards in low- and middle-income countries is a high priority internationally. The proposal addressed in this manuscript is to use the existing knowledge in local universities, private companies, citizen's organizations and to translate its proposals and scientific / technical advices to the national authorities, in a low cost manner. This translation is done by what is described here as Collective Expertise. Collective Expertise, can be a very powerful way to develop local strategies to solve problems and face the challenges of food safety and food security.

Key words

Food safety; Food safety authorities; Collective expertise; Microbial and chemical contamination, Food safety management systems

Highlights

- Analysis of the situation of food safety in low- and middle-income countries
- Proposal of collective expertise to analyse the food safety hazards
- Creation of food safety expertise in low- and middle-income countries

1. Introduction

Availability of food should be sufficient to nourish the global population. Nevertheless, according to international institutions (FAO, IFAD, UNICEF, WFP & WHO, 2017), people with hunger appear to be augmenting, affecting 11% of the global population. In addition, the number of undernourished people globally was 815 million in 2015, against 777 million in former year. Several factors, interconnected and variable, emerging and re-emerging, can explain and at the same time can intensify this continuous problem of food insecurity. Examples of these factors are fragility and conflict, civil insecurity, large-scale displacement, climate-change (i.e. with drought conditions), natural resources degradation, distribution and lack of awareness in the field of healthy nutrition.

Having food must also mean that people are nourished with safe food, so the links between food security and food safety are inextricable anywhere in the world (Jones et al., 2013; King et al., 2017). Internal data on deaths and hospitalizations caused by food do not show that everybody is eating safe food. Recent data reveal that of the 56.4 million deaths worldwide in 2015, more than half (54%) were due to the following 10 causes: ischemic heart disease, stroke, lower respiratory infections, chronic obstructive pulmonary disease, trachea and bronchus cancers, diabetes mellitus, Alzheimer disease, diarrheal disease, tuberculosis, road injury. However, these causes of death differ according to the level of country income. Infectious diseases account for 43% of deaths in low-income countries compared to 1% in high-income countries. In particular, the diarrheal diseases cause 550 million people to fall ill and 230 000 to die every year (WHO, 2017a). Children under 5 years of age carry 40% of the foodborne disease burden, with 125 000 deaths every year.

Moreover, when looking at the data, it has to be taken into consideration that these numbers are only estimates. If in high-income countries statistical institutes collect information on deaths, causes of deaths and on people hospitalized, in many low- and middle-income countries no statistical institute exists, or, when they exists, institutes they are not entirely reliable, consequently the numbers of deaths from specific causes have to be estimated from incomplete data. Statistics on the causes of death and of hospitalizations can help the health authorities to determine the direction of their public health actions, not only because hospitalizations are very expensive for health care

systems, but also foodborne diseases and food contamination can cause huge problems in tourism, trade and on families that do not have health care protection.

Regarding food related health hazards, it is important to have presented some contextual elements of food chains around the world such as, the globalization of the food supply; the increased complexity of those chains; the impact of contaminated food on human health and the impact on the economic well-being of the agri-food industry. It is therefore necessary to assess the hazards and risks associated with food products, throughout the food chains, from production to consumption. Indeed, at each stage, the risks of contamination are significant, when considering the diversity of production systems, the transformation systems, the transport and conservation systems and conditions and the preparation and consumption modes, all in the new context of climate change.

Foodborne illnesses are usually infectious or toxic in nature and caused by microbiological/biological agents or chemical substances through the consumption of contaminated food or water.

The notion of toxicity is a function of a complex relationship between the doses and the effects of an agent but time of exposure and the category of exposed population (i.e children, elderly people and sick people) are also important parameters to consider. In developed countries, it is usual to work on risks to protect population from the hazards. In low- and middle-income countries, risk management is very weak and the population suffers from different food associated hazards. African situation will be the main focus of this article, although some of the problems mentioned here can be extrapolated to other continents.

Food hazards

Microbiological contamination

Among the more than 250 foodborne diseases, the most frequent ones are infectious diseases that are caused by the contamination of food with bacteria, fungi, virus and parasites (WHO, 2015). The most relevant biological contaminants are bacteria (*Campylobacter jejuni*, *Clostridium botulinum* and *Clostridium perfringens*, six *Escherichia coli* pathotypes (Shiga toxin-producing *E. coli* (STEC)—STEC also referred as Verocytotoxin-producing *E. coli* (VTEC) or enterohemorrhagic *E. coli*

(EHEC); Enterotoxigenic *E. coli* (ETEC); Enteropathogenic *E. coli* (EPEC); Enteroaggregative *E. coli* (EAEC); Enteroinvasive *E. coli* (EIEC) and diffusely adherent *E. coli* (DAEC)), *Listeria monocytogenes*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*, *Vibrio* spp.; viruses (such as Norovirus, Astrovirus, Rotavirus, Enterovirus, Hepatitis A and E), parasites (protozoa such as *Giardia duodenalis*, *Cryptosporidium parvum*, *Cyclospora cayetanensis, Toxoplasma gondii, Trichinella spiralis* and amoeboid parasites such as *Entamoeba histolytica*) (CDC, 2018; Koopmans, 2012; Hikal & Said-Al Ahl, 2017). Filamentous fungi (molds) produce mycotoxins that can cause acute or chronic toxicity in human and animals. Mycotoxins can accumulate in maturing corn, cereals, soybeans, sorghum, peanuts, and other food and feed crops in the field and in grain during transportation. Members of three fungal genera, *Aspergillus, Fusarium*, and *Penicillium*, are the major mycotoxin producers (Alshannaq & Yu, 2017). The most common mycotoxins found in food are aflatoxins, trichothecenes, zearalenone, fumonisins, ochratoxins, and patulin, all of them posing ongoing food safety problems worldwide and in special in Africa (Yacine Ware et al., 2017; Manizan et al., 2018). Other toxicologically important mycotoxins, are such as ergot alkaloids, enniatins, alternaria toxins, moniliformin, citrinin, beauvericin, cyclopiazonic acid, roquefortin C, mycophenolic acid, penitrems, verruculogen, griseofulvin or citreoviridin.

Food poisoning can be due to other types of toxins such as ciguatoxins produced by benthic eukaryotic dinoflagellates of the genus *Gambierdiscus,* mycotoxins produced by molds, or toxins produced by bacteria such as *Staphylococcus aureus*, *Clostridium perfringens*, *Clostridium botulinum* or *Bacillus cereus* (Friedman et al. 2017; Martinović, et al., 2016; Liu et al., 2018).

Microbial resistance to antibiotics is another type of food safety hazard because foodborne infections caused by antibiotic resistant bacteria can face possible treatment failure (Lammie & Hughes, 2016; Founou et al., 2018).

Chemical contamination

Because of their usefulness, the chemicals used are diverse but can be dangerous. The chemicals used are very diverse because of their usefulness but can be dangerous. These chemicals can be: 1-products added or generated by food; 2-residues of veterinary drugs, 3-industrial and agricultural pollutants; 4-food contact materials (example of plastic materials migration products) (Rather et al., 2017).

Some of the chemical contaminants are compounds that accumulate in the body, and in the environment, they can be named Persistent organic pollutants. Examples of this type of compounds are dioxins or polychlorinated biphenyls (PCBs). Dioxins for instance cause reproductive and developmental problems, damage the immune system, interfere with hormones and cause cancer. Heavy metals as lead, cadmium and mercury cause neurological and kidney damage.

Legislation and Codex Alimentarius

Due to several food crisis in the 90's of 20th century, the European Union re-accessed completely the food and feed paradigm, with the creation of an integrated approach from production, to transformation and commercialization of either food or feed, the "farm to fork" approach. In 2002, the European Parliament and the Council adopted the Regulation (EC) No 178/2002 laying down the general principles and requirements of food law (General Food Law Regulation, European Commission, 2002a). It also set up an independent agency responsible for scientific advice and support, the European Food Safety Authority (EFSA). Moreover, it created the main procedures and tools for the management of emergencies and crises and also the Rapid Alert System for Food and Feed (RASFF).

The idea behind this overarching and coherent framework for the development of food and feed legislation in each EU country and the EU as a whole was to provide safe food for human and animal consumption, but letting the market act by giving responsibility to stakeholders.

The main set of EU legislation produced for microbiological hazards Regulations are Commission Regulation (EC) No 2073/2005 (European Commission, 2005a) including all its amendments.

The main EU regulatory texts relating to chemical hazards are Regulation (EC) No 1881/2006 on the setting of maximum levels for certain contaminants in foodstuffs (European Commission, 2006), Regulation (EC) No 470/2009 laying down Community procedures for the establishment of residue limits for pharmacologically active substances in food of animal origin (European Commission, 2009a), Regulation (EU) No 37/2010 on pharmacologically active substances and their classification with regard to the limits maximum residue levels in food of animal origin (European Commission, 2010), Regulation (EC) No 396/2005 concerning the maximum limits for pesticide

residues in products of plant and animal origin (European Commission, 2005b), Regulation (EC) No 1107/2009 concerning the placing of products on the phytopharmaceutical market (European Commission, 2009b), Regulation (EC) No 1935/2004 on materials and articles intended to come into contact with foodstuffs (European Commission, 2004), Regulation (EU) No 10/2011 concerning plastic materials and articles intended to enter in contact with foodstuffs (European Commission, 2011), Regulation (EC) No. 1333/2008 on food additives (European Commission, 2008). To these texts which concern foodstuffs is added Directive 32/2002 / EC concerning undesirable substances in animal feed (European Commission, 2002b). All these regulatory documents are regularly updated since their first publication, meaning that all amendments have to be considered as well. The main route of exposure to these environmental contaminants is food from animal origin for dioxins and PCBs (Malisch & Kotz, 2014), marine fish for mercury (EFSA, 2010a), and food from both animal and vegetal origin for lead and cadmium (EFSA, 2009, 2010b). Furthermore, the combined exposure to mixtures of chemicals, which can act synergically, is highly suspected to induce negative health effects worst that the effect expected from the exposure to a single chemical, as it is done currently in toxicological studies (Bopp et al, 2018).

In low- and middle-income countries if a coherent body of legislation concerning food safety is not in place, as the one from EU mentioned above, the countries use *Codex Alimentarius*. *Codex Alimentarius* seeks to provide tools for people to have "safe and good food for everyone – everywhere", especially in the actual context of globalized food distribution and consumption. The Codex has international food standards, guidelines and codes of practice contribute to the safety, quality and fairness of this international food trade. Codex standards are based on sound science provided by independent international risk assessment bodies or ad-hoc consultations organized by FAO and WHO so they can adopted with trust (*Codex Alimentarius*).

WHO along the years has published numerous and very different types of documents that deal with food safety. Those guides, posters, or fact sheets on food safety are all publically available, as well as strategic plans to attack the problem of having unsafe food been eaten by the populations (WHO, 2012; WHO, 2107b; WHO, 2018a-c).

Moreover, training on basic principles of food hygiene on production, distribution, and retailing and even at home have been extensity promoted all over the world by NGOs, governments, universities, and other stakeholders.

2. The challenge

Reasons for continuing situation of existence of foodborne diseases and consequent deaths?

Still in many African countries, the people eat unsafe food and die daily, especially children, due to foodborne diseases. Foods contaminated with microbiological, chemical, physical or other hazards are more prone to be eaten in situations of food insecurity. Numerous reasons can be given for foodborne diseases continue to kill and sent people to the hospitals. Some of them, not pretending to be exhaustive are presented below.

The first one is the lack of data on the identification of the microbial agent or chemical agent that provoked the disease; limited data on severe or minor outbreaks of foodborne diseases. The data would allow a clearer public health policy for treatment and prevention of diseases. A solution to this nonexistence could be the creation of a health statistic agency/department at the government level and preferentially in the Ministries of health.

The second one is the importance of water. Safety of water is critical for drinking and to be used in the production, transformation and preparation process of food. Foodborne and waterborne diseases can be regarded as associated or as separated issues; nevertheless the hazards associated are in many cases the same.

Another very important problem is the public *vs.* private medical assistance in some of low- and middle-income countries. Public hospitals are poorly equipped and are not many; on the contrary, private hospitals have all conditions to provide good treatment. Data from Eurostat (European Union, 2016) on the public expenditure on health (% of budget), an indicator that is expressed as a proportion of total general government expenditure (for European countries, it has been calculated as the proportion of general government health expenditure in total general government expenditure), indicate that in 2013 and 2014, the values in EU countries can be the double or more of values in some African countries (i.e. Morocco 6.0 (2013), Senegal 8.0 (2013), France 14.3

(2014)). Moreover, populations that do have social security, as in EU, access at fair price to health care. So, treating the disease rests in the responsibility of the families, if they have or not resources to go to private hospitals. The problem is more acute in rural areas where people can be very far away from hospitals, have no resources and so are left untreated (Pariyo et al., 2009).

The sensibility of the authorities is also a big problem because of the cost of the social insurances in low-income countries. Many consider that working on food safety has a cost and the return money is negligent simply because the human cost is linked directly to its level of insurance. In high-income countries, the human cost follows a complex calculation linked to the cost of the social security for sick people and the cost of insurances for death people. It is also possible to think to the culture of deaths in Africa that permit to link family (ITUC-Africa, 2012; Ekore & Lanre-Abass, 2016).

Also, the fact that different approaches to food safety are done by academics and by politicians can slow down the improvement of the situation. Academics rely, to study food safety issues, on microbiological and chemical analysis and on the interpretation of those analyses. They are the ones that master the interpretation and such can have knowledge on the hazards and risks faced by the population. Governments and government officials have to decide on food safety issues but do not know how to interpret data in real time.

There is need for the creation of national entities that manage food safety at national level. Manage means, in this context, risks analysis and expertise, proposition to deal the risks and risks communication.

Last, but no least, to face these constraints and ensure prevention and control of food contaminants, it is essential to implement Food Quality Management Systems (FQMS) and Food Safety Management Systems (FSMS), based on the application of the Hazard Analysis and Critical Control Points (HACCP) method and its prerequisites (Good Practices) throughout the food value chains. This has been the strategy of EU and several other countries (USA, Japan, Australia…) that already have these systems in place.

In some countries, namely African countries, where there is a lack of a structured organization and/or legislation for food quality management's systems, as mentioned, the implementation of *Codex Alimentarius* is the first resource for food safety

assurance. But the implementation of some of the proposals, is not always straightforward for SME of the food sector, for local producers and local retailers. The problem is that in some countries most of the enterprises are in fact micro enterprises and people do not have information and formation or skills to establish HACCP systems, do not have financial capacity to perform analysis and national authorities do not have enough resources to accompany so many enterprises. Therefore, there is an urgent need for a systematic/proactive, cost-effective approach towards the control of biological and chemical hazards along the agri-food chains in low- and middle-income countries. Efficient FSMS should take into account the socio-economic context along with the organizational and technological capabilities of the chain stakeholders, including farmers, seed producers, cooperatives, storage and transportation infrastructures, SMEs, as well as market intermediaries and actors.

The implementation of a food safety management system turns out to be a difficult process for many food businesses managers because of the complexity of the available documents and methods. The eastern Mediterranean countries have already pinpointed the deficiencies in their systems and the need to update food safety laws and regulations, food standards and control management, effective food inspection and enforcement services, food monitoring and surveillance systems with adequate laboratory resources, foodborne disease surveillance systems, food safety education and training, and timely information and communications (Alwan & Elmi, 2015). These deficiencies can be extended to many other African and non-African countries.

3. Using Collective Expertise as a methodology to promote food safety

In low- and middle-income countries, knowledge on microbial and chemical contaminants in food chains exists in universities and public or private research institutes. Researchers have, for most of them, done graduate studies, post-docs or advanced training studies outside their countries around the world. Analysis that were done, even if they are not numerous, can be interpreted by those researchers/teachers and then be turned into data that can feed political decisions. Moreover, due to international scientific contacts, internet connection, agricultural and food big data and scientific literature the data from other countries and similar situations can be the source of data that can be related to local situations and analysis of local situations.

So, the proposal is to use as tool the knowledge translation. Transferring the knowledge already existing in local universities, private companies, citizen's organizations, to authorities involved in managing food safety, can be a powerful way to develop local strategies to solve problems and face the challenges of food safety and food security. Transfer could be made through the use of Collective Expertise.

Collective expertise in the scope of this work consists in collecting, sharing and highlighting information available in the universities, in experts working in the field of food safety in private companies and other stakeholders.

Teachers by their function are confronted with all the problems related to these fields. They supervise the internships of the students in relation with the socio-economic world, they are asked to give opinions, or to take part in the resolution of the problems of food safety, as well as various specialized (in charge specifically of the concerned domains) or not specialized institutions (local authorities, companies, NGOs). As a result, they have an informed opinion on all major challenges in the areas concerned. Even if this approach is not based on actual studies, it has the merit of valuing a wealth of information and, precisely, makes it possible to circumvent the requirements of country-wide studies, which are inherently cumbersome, expensive and long.

If gathered and being consulted in groups, teachers from several universities in a country as well as the other stakeholders, become experts belonging to a Collective Expertise panel. These groups of experts due to their different geographical origins and scientific and technical background, will have an accurate idea of the state of food safety in the country. Such a panels will represent, for authorities, a mean of having proposals and scientific / technical advices of interest for the mitigation of the national problems, with minimal costs.

Collective Expertise can be implemented by organizing meeting of experts in different areas related to food safety like, chemistry, microbiology, social sciences, law, and so on. The experts should be around 20-25, being divided in two groups and for two days come up with a list of the major challenges of a country in terms of food safety that can be reported as:

- Identification of the challenge;
- Brief description of challenge;
- The impact – socio-economic, health, science, legal…

- The needs associated – research, equipment, analysis, training and training levels, legislation…

The use of Collective Expertise will allow the country authorities to respond to different challenges such as:

- Increase food safety for local and outside (exports) consumers;
- Develop or improve a local food safety policy and plan of action;
- Share responsibilities between industry, consumers and government;
- Inform consumers to help them make the best choice of food and prepare their food properly;
- Sensitize consumers to be more demanding about the quality of food;
- Strengthen the food control system from farm to table with the participation of stakeholders;
- Increase the level of credibility and competence of regulatory authorities;
- Increase industry and consumer awareness and participation in food safety.

The utilization of Collective Expertise was tested in the scope of the EU project Erasmus+ project (EU) entitled "Societal Challenges and Governance of African Universities: the case of ALIments in Morocco, the Democratic Republic of the Congo and Senegal (DAfrAli)", seeks to strengthen the governance capacity of African Higher Education Institutions to mobilize their resources in order to respond to major societal challenges in relation to external stakeholders. The results of using the methodology Collective Expertise pilot exercises are detailed in a second article untitled: Analysis of societal challenges in food safety by collective expertise in Morocco, the Democratic Republic of Congo and Senegal.

Acknowledgements

This work was supported by the European Union, through the funding of the Eramus+, Key Action No2, project DAFRALI - "Défis sociétaux et gouvernance des universités AFRicaines: le cas des ALIments au Maroc, en République démocratique du Congo et au Sénégal, No 2015/C 347/06. This project is coordinated by AUF Belgium. MTBCrespo acknowledges iNOVA4Health Research Unit (LISBOA-01-0145-FEDER-007344), which is cofunded by Fundação para a Ciência e Tecnologia / Ministério da

Ciência e do Ensino Superior, through national funds, and by FEDER under the PT2020 Partnership Agreement.

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