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Food safety and COVID-19: Limitations of HACCP and the way forward

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Abstract
Food is a basic need for existence and thus the food industry can never be shut even at the time of a pandemic. The COVID-19 pandemic has exposed the lapses in the current food system and it is understood that HACCP based food systems are not effective as desired in reducing the risk associated with unidentified hazards. While HACCP deals with food safety only, in the present scenario there is a need for tools which address all four elements of food protection i.e. food safety, food quality, food defense and food fraud. These elements can be defined and understood as separate concepts yet overlapping interactions are observed. Tools which encompasses various elements of food protection are proposed in recent literature which may be used in combination to develop a more potent and bespoke food protection system for the food industry or organizations. Further, in addition to the use of technological advancement for food protection, utilization of behavioral sciences especially in food safety execution and communication systems process is necessary.

Keywords: HACCP, Food safety, Food protection systems, VACCP, TACCP

Introduction

Food Safety in the light of COVID-19

Novel coronavirus SARS-CoV-2 (commonly known as COVID-19 virus) has caused an unprecedented threat to human life across the globe and World Health Organization (WHO) has declared this widespread fatal respiratory illness due to COVID-19 virus as a global pandemic. Practicing social distancing and implementing partial or complete lockdown are the common measures taken at local and international levels to reduce the transmission of COVID-19 [1]. Restriction on almost all activities involving human gathering is a harsh outcome of the measures taken to stop rapid spreading of COVID-19 and world has gradually adapted to the new ways of industrial functioning which involves less physical and more virtual interactions. People working in food industry can not work from home due to the very nature of the work and virtual interaction cannot be a solution for the industry in its present form. However, it is important to ensure that people working in food industry are not infected by or are carriers of COVID-19 virus as such a crisis may threaten continuous and safe supply of food. The onus lies on all stakeholders working in food industry to not only extend their contribution to maintain continuous and safe food supply, but also to develop and install systems which are resilient against situational anomalies. With special reference to resilience, food industry may review the efficacy of used and available food system models in post pandemic phase as the ongoing crises has exposed the lapses in current food systems and both, Food Safety and Food Security, looks jeopardized. HACCP (Hazard Analysis Critical Control Point) [2] based food safety management system did not suffice to counter the hazards associated with atypical COVID-19 pandemic has compelled food industry to alter their food safety management systems at various levels. As such, HACCP was never designed to work for any unidentified hazard and hence cannot be considered as a resilient model for food safety. It is imperative to the food industry to develop and implement improved models in food systems which can address wider food related issues.

Limitations of HACCP

Integration of Occupational Health and Safety in food safety management system has been advocated by policy makers but till date both are dealt under different umbrellas with separate standards and verification procedures. In addition to a complex HACCP based system for food

safety, the food industry separately battled safety concerns such as slips and falls, knife cuts, soft-tissue injuries, etc. As an "essential industry", food-related organizations now face a unique challenge in controlling exposure to COVID-19. Not only must they keep their facilities clean and employees safe, they must also ensure they do not create additional exposures for their suppliers or customers and this makes the hazardous incident of overlapping nature. This will eventually lead to overlapping responsibilities causing confusion. Also, the possibility of willful transmission of COVID-19 with a malicious intent cannot be ruled out and this remains unidentified in HACCP. HACCP (deals with Food Safety) addresses only one of the 4 elements of a food control system, also known as 4 elements of food protection [3] which are:

(1) **Food defense:** ideologically motivated intentional adulteration that makes the food injurious to health.
(2) **Food fraud:** economically motivated intentional adulteration that may or may not make the food injurious to health. Thus, some food fraud issues may overlap with the definition of food defense whilst others may be a food quality issue.
(3) **Food safety:** unintentional contamination of food that makes the food injurious to health.
(4) **Food quality:** delivery of attributes that influence a product's value to consumers.

This is one of the major limitations of HACCP besides having following disadvantages.

1. Technical, material and human resources are required which are often not available readily.
2. Involves multidisciplinary approach which often not executed by organization.
3. Time taking exercise.
4. Requires cultural changes which is not easy to achieve.
5. System requires consistent up gradation and updating.
6. Subjective conversation needs to be changed in objective form.
7. Involvement of all participants in the food chain is required.

Importance and integration of wider food crimes in Food Management System

The global food safety initiative (GFSI) position paper on mitigating the public health risk of food fraud (July 2014) considers the interaction of food defense, food fraud, food safety, and food quality [4]. The concepts of food safety, food quality, food defense, and food fraud, and their interaction is presented. The diagram (Figure 1) also helps in understanding the ambit of food crimes and interaction between above mentioned 4 elements of food protection.

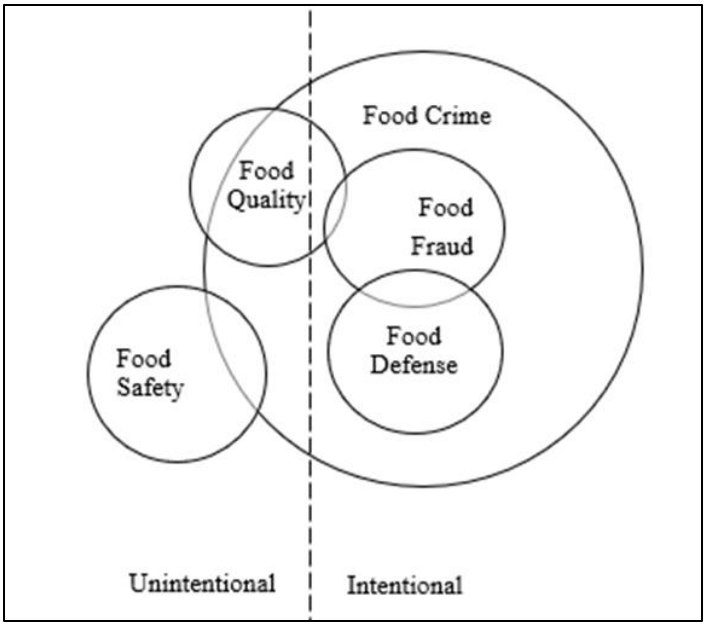

Fig 1: Interaction of various elements of food protection [4]

Food industry in present circumstances requires a more holistic approach that encompasses not only scientific criteria, but also aspects of social science which leads to food crimes. In view of this various food protection models have been proposed which can be used in combinations along with existing HACCP models to broaden the scope of food protection. Some of the novel models proposed in recent literature are briefly discussed below with reference to their objectives, mechanism of action and practicability of implementation.

1. Threat assessment critical control point (TACCP)

The aims of TACCP is to assess threats and prevent behaviorally or ideologically motivated intentional adulteration.[5] Mechanisms of TACCP involves thorough qualitative assessments (likelihood × impact) of threats. Likelihood and impact scores and use of priority matrix in TACCP provides hierarchy for action by risk for organizations. However, one limitation of this model is that TACCP deals with threats assessment within manufacturing environment or within an organization but its practical use to assess suppliers that is, from the point of delivery is difficult [6]. The model can further be evolved to combine threats and vulnerabilities assessment into one system and can be combined under one system.

2. Vulnerability assessment and critical control point (VACCP)

VACCP examines how exposed/susceptible organization or premise is to food fraud incidents and how prevention of intentional economically motivated adulteration.[7] Qualitative

assessments (likelihood × impact) of threats is like that of TACCP. VACCP can be practically used in wider supply chain.

3. Food protection risk matrix

This model differentiates food fraud among other food control elements such as food safety, food defense and food quality [3]. A risk matrix is designed which identifies the cause of risk and the motivations driving the fraud, however, this does not address the effect of the committed fraud. The 4 quadrants in the matrix assist in exploring the criteria. Food Quality- may be caused by mishandling. Food safety - may be caused by unintentional contamination. Food fraud - intentionally done to increase profit margin. Food defense - deliberately carried out to cause harm.

4. NSF fraud protection model

NSF Fraud Protection Model can be used to assist organizations to "think like a criminal"—particularly in assessing vulnerability from the perspective of what is advantageous to the fraudster. Aim of this model is to anticipate the likelihood of fraudulent attack on food products especially according to product value [8]. The mechanism of this model is built on 4 quadrant of Boston consulting group (BCG) matrix. Top right- products most attractive to fraudster. Bottom left- least attractive to fraudster. Size of the circle of a food product represents the perceived difficulty on conducting the fraud. Food industry and regulatory teams can use the model to anticipate which products are most likely to be targeted by fraudsters, the factors for targeting and whether the previous fraud had occurred.

1. USP preventive food fraud management system (USP nd)

This model helps user to develop and implement a preventive system specifically for the adulteration of food ingredients [9]. This involves a structured approach to characterize food fraud vulnerabilities with associated guidance to develop mitigation strategies. Nine contributing factors are considered and how they impact on vulnerability using a matrix approach proposed. Lifecycle approach is proposed for food fraud management. This is a four-step process. First 3 of which are characterized as fraud vulnerabilities associated with an ingredient by occurrence and impact. Last step is guidance.

1. CARVER + shock tool

This tool allows user to think like an attacker and to determine the most vulnerable point within a system or premise to an attack. Therefore, the aim is to focus resources on protecting the most susceptible points in the system [10]. The mechanism is based on the 7 attributes which are scored on a scale of 1 to 10.

Criticality - measure of public health and economic impacts of an attack.

Accessibility - ability to physically access and egress from target.

Recoverability - ability of system to recover from an attack.

Vulnerability - ease of accomplishing attack.

Effect - amount of direct loss from an attack as measured by loss in production.

Recognizability - ease of identifying target.

Shock is a combined measure of economical, psychological and health impacts of an attack.

CARVER + shock tool provides relative risk rankings for nodes/process steps in a production process or national food system. Critical or vulnerable nodes/process steps are identified based on the scores. Preventive measures or mitigation programs to reduce likelihood of attack are prioritized.

Another option in CARVER + shock would be to only use the criticality, accessibility and vulnerability (CAV) scores and facility or process line level.

Emphasis on behavioral science over technological advancement

Many of the advanced and traditional methods used to control and inactivate the level of viruses in food are listed below, however. What can save COVID-19 exposure is not the applications of these technological advancement but people's behavior regarding food safety when purchasing and consuming food. There are specific behaviors that will reduce the risk of viral exposure for ourselves, our co-workers, and our communities. Decades of research show the power of behavioral science in increasing the consistency of safe behaviors. The spread of COVID-19 serves as an important reminder of what food-related organizations can gain by incorporating a behavioral component into a comprehensive exposure-reduction process.

Traditional and modern methods of inactivating viruses in food:

A. High-temperature heating (70 °C) can inactivate viruses, including the Coronavirus. The Coronavirus is active and stable even at -20 °C or less for 2 years. Storing food in the refrigerator (4-8 °C) does not disable the Coronavirus [11].
B. Food-borne viruses can be inactivated by irradiation at doses from 2.7 to 3.0kGy (spices, fruits and vegetables) [12].
C. C. Ultraviolet light (245-285 nm) can protect some foods such as juices, milk, egg, fruits and vegetables surface [11].
D. High-pressure processing (300-400 MPa and 522 °C for 5 min, depending on the type of virus) results in the inactivation of viruses in foods such as fruit juice, shrimp, fish and ready to eat cooked meats (5, 6). E. Using chlorine (0.5 mg/L), ozone gas (concentration of 20-25 ppm) and chlorine dioxide (2.19 mg/L) or 0.1% sodium and calcium hypochlorite for 1 min can inactivate the virus in water and the surface of some food packaging [11, 13, 14, 15].

Apart from having behavior-based food safety process, understanding of behavioral science is also important to prevent criminal activities that may be associated with food industry. Criminal attributes can also be characterized into ideological, occasional, occupational, professional, and recreational types [16]. Economically motivated adulteration, malicious contamination, extortion, espionage, counterfeiting, and cybercrime with an associated typology for individuals that pose a threat is as below:

(1) The extortionist.
(2) The opportunist.
(3) The extremist.
(4) The irrational individual.
(5) The disgruntled individual.
(6) The activist and other cyber criminals.
(7) The professional criminal.

It is important to consider the extent to which food fraud and food defense is put to jeopardy. Criminology and understanding of behavioral science provide a wider insight into the motivation and causation behind food crime. Consequently, the behavioral attributes may also be included in the food system verification process.

Conclusion

The aim of this review is to address the need for modification in existing food protection system for food industry. Discussion on limitations of HACCP reveals that HACCP is not designed to prevent food systems for any unprecedented or unidentified hazard. Further it addresses only food safety and not food quality, food fraud and food defense which are other three elements of food protection. The ambit of food crimes and overlapping nature of food defense, food fraud, food quality and food safety can be understood from interaction of these four elements of food protection. This paper has briefly discussed the existing and more novel tools or food protection models which may be used in combination to develop customized food protection systems for an organization or specific industry. While customizing such a tool, the intent of hazard i.e. motives behind the system failure should also be considered and not only the hazard itself and associated consequences. The organizational weakness in this regard may lead to the installation of a food protection system in an organization, which may not address all the elements of food protection and would be effective only for a narrow range of hazards.

Scope of research and modification of existing tools of food protection was found which, if undertaken, may support the development of global countermeasures over and above the critique discussed in this paper. While it is strongly recommended that food industry should adopt a holistic food protection system considering wider food crimes, this paper also suggest inclusion of behavioral science in verification procedure of a food protection program. As the food industry evolves it also imperative to include within food safety systems the role of the final consumer and communication of food safety measures for added assurance to them. Pandemics like these will cause permanent changes in consumer behavior and habits and the food industry must have visible assurance measures to draw customers back and this is where behavioral sciences again will play a key role.

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