

Food defense and operational health: Protection against Intentional Food Contamination in the Armed Forces

Defensa Alimentaria y Salud Operacional: Protección Contra la Contaminación Intencional de Alimentos en las Fuerzas Armadas

Abstract: The intentional adulteration of the food supply chain is a concern for governments, organizations, and societies, especially after the terrorist attacks of September 11, 2001, resulting in measures against intentional food contamination, known as Food Defense. This study aimed to systematize evidence on threat assessment and procedures that promote Food Defense actions in countries and the Armed Forces. The method consisted of a integrative literature review with searches in the Web of Science, SciELO, Lilacs, and Google Scholar databases. The results of this research reveal the application of concepts on the subject through the adoption of tools, such as software and checklists, with the development of Food Defense systems. In the government area, initiatives related to the implementation of legislation on intentional food contamination are incipient, except for the United States of America. In Brazil, it is necessary to address the Food Defense subject as a national security policy to preserve the operational health of the military.

Keywords: Food Defense; Armed Forces; Operational Health; Intentional Food Contamination.

Resumen: La adulteración intencional de la cadena de suministro de alimentos es una preocupación de gobiernos, organizaciones y sociedades, principalmente a partir de los atentados terroristas del 11 de septiembre de 2001, lo que motivó la adopción de medidas frente a este proceso de contaminación, que pasó a denominarse defensa alimentaria. El objetivo de este artículo fue sistematizar las evidencias en cuanto a la evaluación de amenazas y procedimientos que promuevan acciones de defensa alimentaria en países y Fuerzas Armadas. El método consistió en una revisión integrativa de la literatura, con investigación en las bases Web of Science, SciELO, Lilacs e Google Académico. Los resultados revelan la aplicación de conceptos sobre el tema mediante el uso de herramientas, como software y listas de cotejo, con el desarrollo de sistemas de defensa alimentaria. A nivel gubernamental, las iniciativas relacionadas con la implementación de legislaciones sobre la contaminación intencional de los alimentos son incipientes, con la excepción de los Estados Unidos de América. En Brasil, por su parte, es necesario tratar la defensa alimentaria como política de seguridad nacional para preservación de la salud operacional del efectivo militar.


Palabras clave: Defensa Alimentaria; Fuerzas Armadas; Salud Operativa; Contaminación intencional de alimentos.

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1 INTRODUCTION

The global population is expected to reach at least nine billion inhabitants by the year 2050, requiring up to 70% more of the resources currently used. This will create the need for other productive food systems and the development of sustainable logistics articulations (FRITSCHÉ, 2018).

According to Pitaluga and Le Bourlegat (2022), the food system is the junction of elements and activities related to production, processing, distribution, preparation, and consumption, with particularities intrinsic to the food supply chain. This configuration presents a continuous increase in complexity, diversity, and interdependence of domestic and global systems, with the development of risk management strategies to protect food supply processes from possible adulterations, regardless if intentional or not, establishing parameters in order to minimize economic impacts and public health problems (ANDRADE; OLIVEIRA; SILVA, 2021).

For decades, the intentional contamination of food has been a concern to various sectors in developed countries. In December 2004, at a press conference in which he would announce his departure from the U.S. Department of Health and Human Services, then-secretary Tommy Thompson questioned why terrorists had not attacked the food chain in American territory, “because it was so easy to do” (NATIONAL ACADEMY OF SCIENCES, 2006). The World Health Organization recognizes the intentional contamination of food as one of the greatest health threats of the 21st century, which can be used as a tool for terrorist attacks (WORLD HEALTH ORGANIZATION, 2007).

The issue of Food Defense is an important topic in protecting businesses and consumers from internal and external threats (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, 2019), especially after September 11, 2001, which has since brought a concern about food supply chain security to governments, organizations and societies worldwide. The topic of food defense relates to all forms of malicious action to contaminate batches or supply chains (MANNING, 2023). The United States Food and Drug Administration (FDA) (2022) defines food defense as the effort to protect food from acts of intentional adulteration.

The potential impact of intentional contamination on human health can be estimated by extrapolating the many documented examples of unintentional outbreaks of Food and Waterborne Diseases (FWD) (SOBEL, 2005). However, some typical cases of intentional contamination have gained repercussions among consumers. For example, the contamination of lots of strawberries with needles in Australia in 2018, which brought a very negative impact on the product with economic losses and the drastic reduction of consumption due to the loss of confidence in its sanitary quality.

According to Andrade, Oliveira and Silva (2021), there is a knowledge gap about which food defense strategies need to be addressed, with the need for organizations in the food chain to adopt different defense plans. To identify these strategies, it is important to recognize the different agents that can be qualified as threats, and which are classified by Manning (2023) into five categories: agents that practice espionage; extortion; sabotage; extremists and activists.

Causing food shortages has always been a method of warfare, with the restriction or destruction of food being a way to obtain military advantage either by offensive or defensive actions, and that not infrequently determines the results of a battle (SEVERINO; ALMEIDA, 2017).

The objectives of this article were to systematize the evidence on the evaluation of threats and procedures that promote actions in food defense, ensure the food supply chain protection against intentional contamination; the protection of health and operability in the Brazilian military and abroad, as well as present the history and concepts of food defense addressed by different organizations and researchers.

2 METHODS

This article was developed by means of an integrative literature review through research conducted by the authors. The research sought initial information of a reality for the formulation of hypotheses on the reality of food defense. Bibliographic sources, documents, laws, regulations and technical references were used. In addition, existing systems related to food defense were studied.

The following guiding question was used to complete the research: what are the evidence, concepts and actions in Food Defense used in the military and civilian environments of different countries? With this, the history of incidents of intentional food contamination, as well as the possible characteristics of the individuals who carry out these actions were considered. For the selection of the studies, the PICO (Participant, Intervention, Comparison, and Outcome) strategy was chosen, according to Schweitzer et al. (2016), and described in Table 1. The elaboration of the research question and the literature search allowed obtaining the best information available and directing the literature review performed. Finally, it is emphasized that the search was limited to articles written in English and Portuguese.

Table 1 - Inclusion criteria adopted by means of the PICO strategy

Acronym	Definition	Description
P	Participants	Military and Civilian Agencies
I	Intervention	Analysis of actions (procedures) in food defense in the military and civilian environments of various countries, in face of intentional food contamination
C	Comparison	Situation of food defense in Brazil and in other nations (civil and military environment). History of malicious actions of food contamination in Brazil and in the world
O	Outcome	Armed Forces presenting functional food defense plan

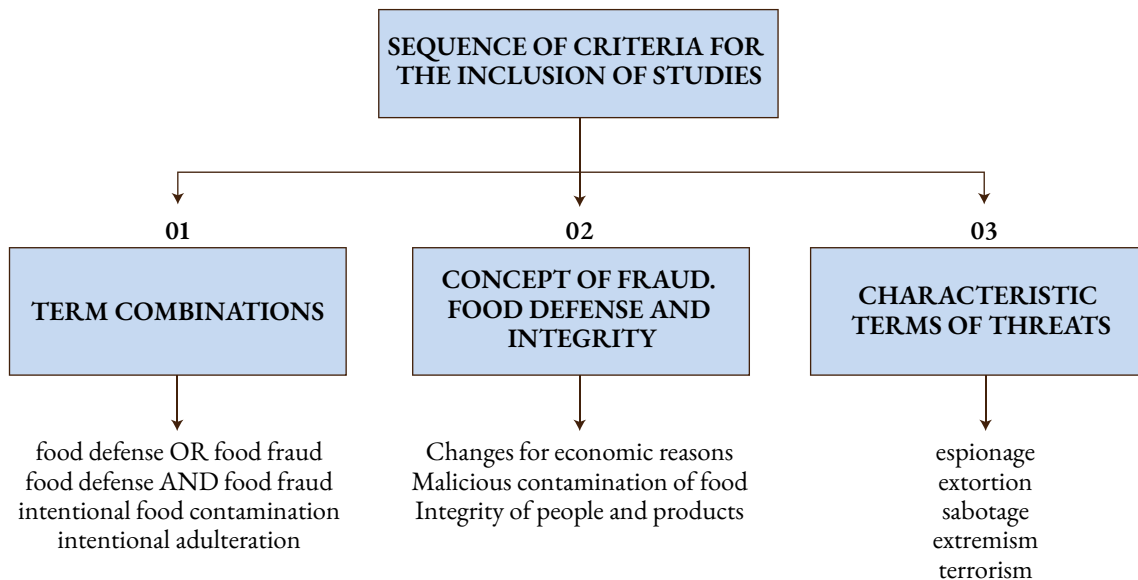
Source: Prepared by the authors, 2023.

A retrospective observational study was conducted, organized according to the Preferred Reporting Items for Systematic Reviews and Meta Analysis (Prism), based on the literature on food defense.

Literature review was independently performed by the main author and a researcher, assisted by a selection of studies published in Pubmed; Capes; Scielo; Lilacs; Web Science and Google Academic, using the same search criteria for all databases. Regarding the location of the articles, the following combinations were used: food defense OR food fraud AND food defense AND food fraud OR intentional food contamination AND intentional adulteration. The references of eligible studies were analyzed to find other publications of interest by the cross-reference method.

Thus, the inclusion factors were defined according to the words and combinations essential to the search, the conceptualizations needed to understand the factors linked to intentional food adulteration, and the key characteristics intrinsic to the types of threats of this intentional contamination. After the search, the articles were selected by title and abstract. Figure 1 presents the sequence for establishing the criteria for inclusion of studies in the search.

Figure 1 - Sequence of Criteria for Including Studies



Source: Prepared by the authors, 2023.

There was no limitation as to the period of publication, in order to contemplate the scientific production up to the time of the research.

After reading the title and abstract, we adopted as exclusion criteria the studies that predominantly focused on food safety, whose concepts refer to unintentional contamination of food.

Reading the articles in their entirety was the final step of inclusion. Original articles meeting the inclusion and exclusion criteria were consulted and selected. The search was conducted

from February 2018 to September 2022. The levels of evidence were ranked according to the Grid system of the *Methodological Guidelines* handbook of the Brazilian Ministry of Health (BRASIL, 2014), presented in Chart 1.

Chart 1 - Ranking of levels of evidence

LEVEL	DEFINITION	IMPLICATIONS	SOURCE OF INFORMATION
HIGH	There is strong confidence that the true effect is close to the estimated one	It is unlikely that additional work will change confidence in the effect estimate	- Well-designed clinical trials with a representative sample - In some cases, well-designed observational studies with consistent findings
MODERATE	There is strong confidence that the true effect is close to the estimated one	Future work may change confidence in the effect estimate, and may even modify the estimate	- Clinical trials with mild limitations - Well-designed observational studies with consistent findings
LOW	Limited confidence in the effect	Future work is likely to have a major impact on our confidence in the effect estimate	- Clinical trials with moderate limitations. - Comparative observational studies: cohort and case-control
VERY LOW	Confidence in the effect estimate is very limited. There is an important degree of uncertainty in the findings	Any effect estimate is uncertain	- Clinical trials with severe limitations - Comparative observational studies with presence of limitations - Non-comparative observational studies Expert opinion

Source: Brazilian Ministry of Health (2014).

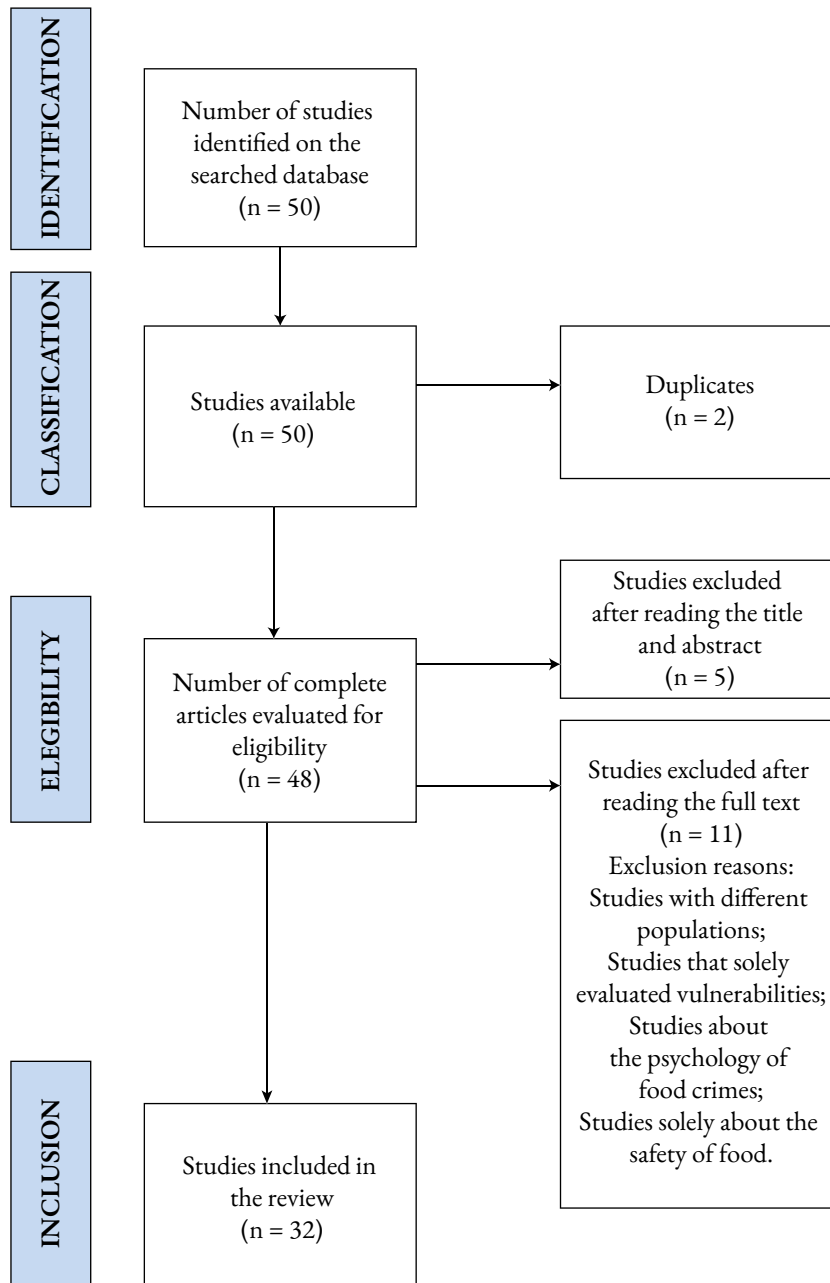
3 RESULTS AND DISCUSSION

The objectives of this article were to systematize the evidence on the evaluation of threats and procedures that promote actions in food defense capable of ensuring the food logistic chain protection against intentional contamination; the protection of health and operability in the Brazilian military and abroad. In addition, it intends to present a history regarding voluntary contamination, and to investigate some food defense concepts addressed by different organizations and researchers.

In total, 32 articles were included in the final review, as indicated in the flow diagram (Figure 2). The results of this review show the diversity of the variables between the types of malicious threats practiced, of system vulnerabilities, and the strategies used for analysis and adoption of measures related to food defense.

The total of 12 studies surveyed addressed tools for applying food defense checklists in a system, infrastructure, or mass food service, enabling assessing the risk of intentional food contamination and their levels of evidence, as shown in Table 2.

Figure 2 - Flow diagram of the studies included in the integrative literature review



Source: adapted from Moher et al., 2009

Table 3 presents 20 studies included in the review after evaluation for inclusion in this article. The studies listed in Tables 2 and 3 were those included in the review (n = 32). Based on the results obtained in the use of these tools (Table 2) and, together with the application of the conceptual bases (Table 3), the conditions for adopting measures that promote actions in food defense and ensure the protection of the food supply chain were provided.

Table 2 - Included studies addressing tools for assessing requirements in Food Defense and levels of evidence

STUDY	CHARACTERISTICS OF THE SAMPLE	ACTIVITY	EVALUATION	RESULT	LEVEL OF EVIDENCE
United States Department of Agriculture (2007)	Animal product trading facilities in the United States of America	Poultry and cattle slaughtering	Evaluation of vulnerabilities in Food Defense in the audited facilities	Reduction of the risk of malicious action during poultry and cattle slaughter operations in facilities in the United States of America	HIGH
United States of America (2009a)	Animal products slaughtering and processing facilities in the United States of America	Animal product trading facilities in the United States of America		Reduction of the risk of malicious action during processing and storage of products of animal origin in the United States of America	HIGH
United States of America (2009b)	Food companies in multiple nations	Food supply chain		Worldwide use of free software Carver + Shock Primer	HIGH
Indiana State Department of Health (2011)	Producing, processing, and food service facilities in the state of Indiana (USA)	Food Supply Chain in the State of Indiana (USA)	Company's suppliers evaluation	Standardization of the statewide food defense evaluation method	HIGH
United States of America (2012)	School feeding facilities in the United States of America	Education		Reducing the risk of intentional contamination or adulteration of school food	HIGH
Kraft Foods (2015) (Current Kraft Heinz)	Companies supplying ingredient to prepare food products	Food company		Adoption of procedures to prevent the receipt of raw materials contaminated by malicious action	LOW

continue

Table 2 – Continuation

STUDY	CHARACTERISTICS OF THE SAMPLE	ACTIVITY	EVALUATION	RESULT	LEVEL OF EVIDENCE
DLA Troop Support (DEFENSE LOGISTICS AGENCY, 2016) Combat logistics support agency for the United States of America military forces	Food suppliers under contract with the Defense Logistics Agency	Food supply chain	Auditing companies on the implementation and application of the fundamentals in Food Defense by companies supplying food to military organizations	Reducing risks of receiving intentionally contaminated foodstuffs by military troops supported by the agency	HIGH
<i>Universidade de Lisboa</i> (PORTUGAL, 2017)	Food industrial plants in Portugal	Animal products industry	Evaluation of the implementation of food defense requirements	Food defense checklist for food industry operator developed and applied	MODERATE
Severino, Almeida (2017) Food Defense: Management systems against food terrorism	Companies in the supply chain	Research and Development	Management systems against food terrorism	Reducing the risk of food terrorism actions	MODERATE
British Standards Institution PAS 96 (2017)	Food companies	Food supply chain	Evaluation of threats and vulnerabilities in Food Defense	Protection of the integrity and sanity of food and food chain Food Defense	HIGH
Portuguese Army (2017)	Food services of the Portuguese Army	Military		Adoption of procedures to eliminate risks of intentional food contamination in peacetime and military operations of the Portuguese Army	HIGH
NATO (2019)	North Atlantic Treaty Organization (NATO) food services.	Military		Adoption of procedures to eliminate risks of intentional food contamination and maintenance of operationality in the different Operations of the organization	HIGH

Source: Prepared by the authors, 2023.

Table 3 - Studies included in the integrative review addressing conceptual issues

STUDY	GROUP OF INTEREST	ACTIVITY	OBJECTIVE	RESULT
World Health Report (2007)	World Health Organization Member States	Health protection	Promote international discussions and exercises on bioterrorism	Identification of risks and methods of containment and control
World Health Organization (2008)	World Health Organization Member States	Food preparation, production and processing	Warn the Member States about the possibility of food being used as a vehicle for terrorist acts, and provide guidance on countering, preventing, and responding to such acts	Guide to strengthening, preventing, and responding to acts of food terrorism
Mara; McGrath (2009)	The United States Army	Military logistics	Discuss the most vulnerable areas of the United States military food supply and Food Defense for troops stationed outside the U.S. Territory	Guide to the American Food Defense system in the processes of procurement, preparation, and protection at U.S. military installations
Dalziel (2009)	Food supply chain	National Security	Comprehensively examine and systematize all incidents of malicious and intentional contamination of the supply chain, where the supply chain is a vehicle for dissemination of these chemical, biological physical and nuclear agents	Production of survey material on intentional contamination of the food supply chain at global level
Association Française de Normalisation (2015)	French food production chain	Food preparation, production and processing	Promoting Food Defense in the French supply chain	Guide for protecting the French food chain against malicious, criminal or terrorist actions
Manning; Soon (2016)		Research	Conceptual literature review	Finding contradictory definitions in literature; comparing and contrasting existing food crime risk assessment tools and their application

continue

Table 3 – Continuation

STUDY	GROUP OF INTEREST	ACTIVITY	OBJECTIVE	RESULT
Severino; Almeida (2017)	Food production chain in Portugal and Portuguese-speaking countries	Food preparation, production and processing	Discuss methodologies against intentional food contamination	Guide on integration of food safety management systems
Davidson, <i>et al.</i> (2017)	European food production chain	Food supply chain at pre-retail stage	Analyze how food defense contributes to the integrity of the food supply chain	Demonstrated how Food Defense should be an integral part of food supply chain integrity, rather than just an afterthought after an incident
Ministry of Defense (BRAZIL, 2018)	Military personnel from Brazil's Navy, Army, and Air Force	Military logistics	Discuss the implementation of the Food Defense system within Brazil's military scope	Creation of the working group on Food Defense of the Ministry of Defense
United States of America (2018)	Food facilities in the United States of America	Food safety and inspection service	Develop a 4-phase food defense plan	Functional Food Defense Plan
Figueira (2018)	Meat seasoning production companies	Education and research	Describe the possible forms of intentional contamination in the inputs used in meat seasoning production plant	Identifying vulnerability and creating Food Defense plan for meat product input factory
Moerman (2018)	Agriculture and food production industry	Education and research	Providing an overview of different targets prone to acts of intentional food contamination	Guidance on Food Defense in practice in the phases of operations, receiving, storage, processing, packaging, and shipping of products
Manning (2019)	Food facilities	Research	Positioning Food Defense as a supply chain risk mitigation strategy	Production of material refining the taxonomy of food defense threats

continue

Table 3 – Continuation

STUDY	GROUP OF INTEREST	ACTIVITY	OBJECTIVE	RESULT
Chammem; Issaoui; De Almeida et al. (2019)	Food industry at all stages and consumers	Research	Discussing the regulatory characteristics of food control agencies, in different regions of the world	Production of material on the subject
Lopes, et al. (2020)	Dairy processing industry	Education and research	Assessing the perception of the Brazilian dairy processors regarding food defense	In the view of the companies audited in Brazil on Food Defense, external safety was the most important (84%), followed by personal safety (82%), generalities (81%), and internal safety (74%)
Centre for the Protection of National Infrastructure (2021)	The UK agriculture sector	Security of the UK infrastructure areas	Providing protection to areas considered critical to the UK infrastructure, including agriculture	Protection of physical and cyber facilities
Alves (2021)	The European Union agriculture sector	National security and defense	Food Defense as an instrument of prevention against agroterrorism, terrorism and food crime in the European Union	Production of material exposing the possibility of using pathogens in supply chains
Praia; Henriques (2021)	Meat food industry in Portugal	Research	Food Defense Audits in meat products industries	Verification of vulnerabilities and non-existence of food defense plans
Rapid Alert System for Food and Feed (2022)	Food chain in the European Union member countries	Food safety in the European Union	Promote exchange of information between the European Union Member Countries in support of health authorities for a rapid reaction in cases of public health risks	Food protection in the European Union Members

Source: Prepared by the authors, 2023.

continue

3.1 History

History describes several examples of supply disruptions or purposeful food contamination being used as military attacks on the enemy (BUCHANAN; APPEL, 2010). The importance of logistical support has long been considered vital to staying in combat, legitimizing the famous phrase asserted by Napoleon Bonaparte: “An army marches on its stomach” (BRAZIL, 2019a).

The history of intentional contamination events is highlighted in the studies presented by Dalziel (2009), Severino; Almeida (2017) and Praia; Henriques (2021) (Table 3).

During the siege of Leningrad in World War II, Hitler sought extermination by starvation of the dominated populations, as recorded by Max Hastings (2012):

Professor Ernst Ziegelmeyer of the Munich Nutrition Institute - one of the many scientists who gave diabolical advice to the Nazis - was consulted about the practicalities (imposing starvation on Leningrad). He agreed that there was no need for a battle; it would be impossible for the Russians to provide their besieged citizens with more than 250 grams of bread per day, a ration insufficient to sustain human life for an extended period of time. (HASTINGS, 2012, p. 183-184)

In 2001, material found at the Tarnak farm training camp in Afghanistan suggested the interest of the terrorist group Al-Qaeda in pathogens of plant and animal origin (DALZIEL, 2009).

From 1998 to 2008, the following agents have been identified as being involved in deliberate food contamination events: arsenic, cyanide, feces, herbicide, household cleaning chemical, insecticide, nicotine sulfate, pesticide, rodenticide, and tetramine. It is worth noting that some countries have already experienced intentional contamination events with repercussions on public health, for example, Australia, Canada, China/Hong Kong, Iraq, Italy, Japan, Korea, the Philippines, Taiwan, Thailand, and the United States of America (DALZIEL, 2009).

In Brazil, the Figueiredo Report describes that the *Cinta Larga* tribe in Mato Grosso would have been exterminated in July 1963 due to dynamites thrown from an airplane toward the indigenous community. In addition, it is known that strychnine, a toxic substance, was added to sugar. This crime became known as the Massacre of Parallel 11, resulting in 3,500 indigenous deaths (VANÇAN; RODRIGUES, 2021).

In 1981, Spain had one of the largest outbreaks in history, in which a case called Toxic Oil Syndrome was reported, leaving 19,904 people sick and more than 300 people dead. The Raelca company was distributing olive oil characterized as pure, but in a suspect product denatured rapeseed oil was found with 2% aniline mixed with animal and vegetable fat (MCKAY; SCHARMAN, 2015). This case refers to a crime against public health, due to an adulteration for economic reasons (food fraud).

In 1989, a shipment of grapes from Chile was identified as being contaminated with cyanide. An anonymous tip made to the United States Embassy in Santiago alerted the authorities about the potential intentional contamination. The FDA banned imports of fruit produced

on Chilean territory, including nectarines, plums, peaches, apples, pears, raspberries, and strawberries, among others. At the time, fruit exports represented the second most important economic activity in the Latin American country. The incident resulted in the loss of US \$300 million in revenue, and consumers became suspicious of products of Chilean origin (FOOD AND DRUG ADMINISTRATION, 2015).

In the last three decades, there have been some cases caused by the deliberate use of biological agents. Noteworthy is the salmonellosis outbreak that, in 1984, affected 751 people, with 45 hospitalizations due to contamination of a restaurant salad buffet perpetrated by an Indian religious sect (RAMBAUSKE; CARDOSO; NAVARRO, 2014).

In 2018, Australia investigated a series of cases in which sewing needles were found inside strawberries sold at retail, a fact reported in at least six states and territories. One man was taken to hospital after eating one of the fruits. Several brands of the product have been pulled from the country's shelves, while New Zealand's largest supermarkets have stopped selling Australian strawberries as a precautionary measure. At the time, Australia's Minister of Health, Greg Hunt, said that such an action was a brutal crime as well as an attack on the public. In 2018, Australia revised its food protection regulations based on these incidents of intentional adulteration (BASHURA, 2020).

Brainard and Hunter (2016) verified 84 incidents of water supply poisoning, of which 65% were against the consuming community and 9.5% affected the water supply of police, military, or refugees. With regard to food, the authors report that out of a total of 224 attacks, 25% were unaccounted for; 22% were for extortion; 10% were for other financial reasons; 16% were politically motivated; 9% were malicious attacks; 5% were for labor disputes, and 12% were for other reasons.

Chart 2 lists some incidents in which malicious actions of intentional food contamination had repercussions in the media for the consequences (social, political, economic or health) of the malicious act.

Chart 2 - Incidents of intentional food contamination with media repercussions and their motivations

Date	Site	Event	Motivation
1984	Oregon (USA)	<i>Salmonella</i> sp. contamination in ready-to-eat salads in a restaurant	Boycott of local elections by the Rajneesh sect
1990	United Kingdom	Food contamination with glass and razor blades	Malicious contamination
2005	England	Contamination of bread with needle fragments	Malicious contamination
2008	China	Infant milk powder adulterated with melanin	Economic Motivation
2013	Not reported	Substitution of alcoholic beverages with acids	Malicious contamination
2018	Australia	Series of cases where sewing needles were found inside strawberries sold in retail	No rational reason for the action

Source: Adapted from Dalziel (2009); Severino; Almeida (2017); Praia; Henriques (2021).

3.2 Concepts

The concepts of safety, accessibility, defense, fraud and quality share some semantic features, and hold proximity to each other when it comes to food area (SEVERINO; ALMEIDA, 2017).

The term food safety, associated with food sanitary safety, refers to the conditions and practices to preserve the safety of food in the production chain. Its goal is to pay attention to biological, physical or chemical hazards in order to avoid contamination and food- and water-borne illnesses (DTHA) (SEVERINO, 2016).

In turn, food security (accessibility) is defined by the World Health Organization(2002) “as sufficient, safe access to food with sufficient nutrients to maintain people’s health and life”. The concept of accessibility is multidimensional and refers both to the security of food supply and the physical and economic accessibility of nutritious food (SEVERINO; ALMEIDA, 2017).

Food fraud, in turn, including the subcategory of economically motivated adulteration (EMA), is an intentional illegal action for economic gain (SPINK, et al., 2019). Incidents of this type of fraud pose a considerable threat to the economic stability of the agri-food industry, as well as the health and welfare of consumers (LEE; FENOFF; SPINK, 2021).

The broader concept of food quality refers to the characteristics that determine the value of the product for customers and consumers, and the ability of food to satisfy the needs of those who consume it (SEVERINO; ALMEIDA, 2017). According to Moerman (2018), food quality also refers to the technical specifications of a given food.

The Institute of Food Science & Technology (2018) understands that food integrity is associated not only with the nature, composition, quality, and safety of food, but also with other aspects of production, including modes of procurement and distribution. Manning and Soon (2016) describe four types of food integrity issues: (i) product integrity (authenticity); (ii) process integrity; (iii) people integrity; and (iv) data integrity.

According to the Food Safety System Certification 22000 (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, 2019), food defense is an important topic for protecting businesses and consumers from internal and external threats.

There are several definitions of food defense by technical entities and official bodies, and all have similarities in their fundamentals. Table 4 presents these concepts and their different objects.

According to Robson et al. (2021), all concepts about food defense refer to actions to protect against willful contamination whose purpose is to cause some kind of harm.

Table 4 - Concepts in Food Defense

REFERENCE	CONCEPT	CONCEPT OBJECTS
British Retail Consortium (2015)	It considers Food Defense as the procedures adopted to ensure the safety of raw materials and products against malicious contamination	Certifiable standards and new methodologies in Food Defense
Manning; Soon (2016)	Food Defense reflects the protective activities and/or the process or procedures that ensure product safety regarding intentional acts of adulteration	Food fraud and Food defense
PAS 96 (2017)	These are procedures adopted to ensure that food and beverage and their supply chains are protected from ideological or malicious attacks leading to contamination or disruption of supply	Types of threats to the supply chain; describes threat evaluation and critical control points
GFSI (GLOBAL FOOD SAFETY INITIATIVE FOUNDATION, 2017)	Process for ensuring the safety of food and beverages regarding all forms of intentional malicious attacks, including those ideologically motivated that lead to contamination	Types of supply chain threats
FDA (2009)	It is the effort to protect food from intentional adulteration through acts intended to cause large-scale harm to public health, including acts of terrorism targeting the food supply	Prevention of actions against food terrorism, agroterrorism, national security and defense, and supply chain protection
Moerman (2018)	Food Defense focuses on reducing the occurrence and impact of intentional contamination or adulteration of food that is politically, economically motivated, or revenge-based	Framework in Food Defense from "field to plate"

Source: the authors (2023).

3.3 Food Defense and the International Reality

The global food trade is very connected, and a country's food supply must be domestically monitored to prevent contamination, adulteration, and fraudulent activities (LOPES et al., 2020). This trade is complex and constantly evolving. Due to discrepancies in the food law systems of different countries, the standardization of international food safety rules is of utmost importance to reduce trade barriers (PRAIA; HENRIQUES, 2021).

The studies presented in Table 3, such as World Health Organization (2002, 2007), Dalziel (2009), Moerman (2018), Manning (2019) approach food defense as a topic of international relevance in the military and civilian spheres.

Intentional contamination can have diverse origins and be caused by employees or individuals external to the food preparation environment, such as members of terrorist groups (BRITISH STANDARD INSTITUTION, 2017). Furthermore, this adulteration can be the result of a process of food counterfeiting or product detour (PRAIA, 2017).

Another possibility is the specific activity linked to agroterrorism, an action perpetrated by a person or a group aimed at destroying the agricultural industry and/or disrupting a country's food supply (MOERMAN, 2018). Food terrorism is an act of deliberate post-harvest contamination, in which the product is adulterated with chemical, physical and biological agents or radioactive material in order to cause illness or death in the civilian population, in addition to causing social, economic and political instability (WORLD HEALTH ORGANIZATION, 2008).

In recent years, regulatory authorities, food companies and consumers have glimpsed the need to develop effective defense systems regarding these products (DAVIDSON et al., 2017). Given this reality, food business operators have been required to develop and implement defense strategies and thus ensure market entry by having their management systems certified by specialized companies (MANNING, 2019).

The importance of food defense has been recognized by becoming a requirement in global certifying standards, such as International Featured Standards (IFS) (INTERNATIONAL FEATURED STANDARDS, 2020), British Retail Consortium (BRC) (BRITISH STANDARD INSTITUTION, 2017) and Food Safety System Certification 22000 (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, 2019), as well as in government strategies, for example, those adopted by the FDA, the American body responsible for controlling and regulating the production of food and medicines in the United States (CAVALHEIRO; RUIZ, KUSHIDA, 2021).

After the event of September 11, 2001, several countries started to adopt measures against malicious actions in food. In China, the Certification and Accreditation Administration (CNCA) - established under the administration of the Supervision of Quality, Inspection and Quarantine (AQSIQ) - has published 40 guidelines and some requirements for regulating food defense plans for export companies. It is worth noting that both the United Kingdom and Germany also have robust food defense initiatives (MOERMANN, 2018).

In late 2001, the FDA and the United States Department of Agriculture (USDA) tried to determine the readiness of the U.S. food system against an intentional attack, thus emerging the first law passed in June 2002, also known as the Public Health Security and Bioterrorism Preparedness and Response Act (SEVERINO; ALMEIDA, 2017).

The Asia-Pacific Economic Cooperation (APEC) Counter-Terrorism Force (CTTF) started examining this issue in 2006, with initiatives to mitigate the food supply terrorism threat (DALZIEL, 2009).

3.3.1 Food Defense in the United States of America and European Countries

Cited in Table 3, the studies by Mara; McGrath (2009) and USDA (2018) address food defense in the United States of America. In addition, analyses by the *Association Française de Normalisation* (2015); Severino; Almeida (2017); Davidson, et al. (2017); Centre for the Protection of National Infrastructure (2021); Alves (2021); Praia; Henriques (2021); Rapid Alert System for Food and Feed (RASFF) (2022) in European countries.

The United States of America considers the food and agriculture industry as one of the 16 critical infrastructure sectors, and the USA is the country where the concepts of food defense emerged. The FDA plays a leading role in various initiatives to protect food from acts of intentional and unintentional adulteration, as well as to help organizations prevent, prepare for, respond to, and recover from acts of intentional adulteration of the food supply (FOOD AND DRUG ADMINISTRATION, 2022). The Federal Bureau of Investigation (FBI) has already demonstrated concern about the dangers related to agroterrorism and food terrorism and their consequences, promoting workshops on the subject among several state and non-state agencies (FEDERAL BUREAU OF INVESTIGATION, 2007).

After the September 11, 2001 attacks, food defense gained legal consistency through the Public Health Security and Bioterrorism Preparedness and Response Act in 2002. In January 2011, a new legal framework was adopted for food safety in the United States through the Food Safety Modernization Act (FSMA), when the development of management systems for food supply defense, analysis methodologies, support software, and educational resources was intensified (SEVERINO; ALMEIDA, 2017).

The United States Food Safety and Inspection Service has functional food defense plans, an important tool that a producer can use to prevent, protect, mitigate, respond, and recover from an intentional contamination incident (UNITED STATES OF AMERICA, 2018).

Several actions are taken by various agencies and institutes around the country, such as the National Center for Food Protection (FOOD PROTECTION AND DEFENSE INSTITUTE, 2022), which has developed multidisciplinary research and guided programs that address the vulnerabilities of the nation's food system to attacks by intentional contamination with biological or chemical agents. The Indiana State Department of Health (2011) presents a food protection program with a food defense section. The FBI (2014), with the FDA participation, has held a few workshops demonstrating the real threat and the devastating effect of a successful malicious food contamination action.

Although the threat of intentional and malicious contamination is a reality of food terrorism, European policy-makers have not yet legally defined food defense, let alone framed it in legislation (ALVES, 2021). According to Moermann (2018) there are few government regulations that deal with food defense.

In Portugal, issues regarding vulnerabilities are contained in the strategic concept of national defense (PORTUGAL, 2013). The legal framework of food defense in Portugal will be done through the European food legislation. However, companies certified by BRC Food, IFS Food and FSSC 22000 standards present a more robust concept regarding food defense (SEVERINO; ALMEIDA, 2017).

France has the methodological guide *Protection de la chaîne alimentaire contre les risques d'actions malveillantes, criminelles ou terroristes*, which was prepared by the French Association of Technical Standards (ASSOCIATION FRANÇAISE DE NORMALISATION, 2015), which formed a pool of organizations to reflect on the

solutions they could implement within a Food Defense approach, considering, above all, the requirements of the IFS Food 6.

In the United Kingdom, the Critical National Infrastructure (CENTRE FOR THE PROTECTION OF NATIONAL INFRASTRUCTURE, 2021) has identified the food sector as one of 13 sectors necessary for the functioning of the country. Unlike the continental Europe, the United Kingdom has followed the United States in food defense (SEVERINO; ALMEIDA, 2017).

As part of the studies and discussion, the British Standards Institution (2017) published the PAS 96:2017, i.e. a guide intended to protect and defend food and drink from deliberate attacks.

3.3.2 Food Defense in Brazil

Brazil is internationally recognized for its agricultural vocation. It produces and exports meats, fruits, cookies, chocolates, wines, *cachaça*, special coffees, organic products, honey, dairy products, nuts and other products, which support the image of a competitive, innovative and sustainable country (AGÊNCIA BRASILEIRA DE PROMOÇÃO DE EXPORTAÇÕES E INVESTIMENTOS, 2022). In the food sector, the National Health Surveillance Agency (*Agência Nacional de Vigilância Sanitária*, Anvisa) coordinates, supervises, and controls the activities of registration, inspection, surveillance, and risk control, and is responsible for establishing norms and quality standards (BRASIL, 2022). This agency has a library that gathers documents and all the current food regulations. Added to this is the fact that the Ministry of Agriculture, Livestock and Supply (Mapa) performs activities throughout the country related to the areas of safety, quality and fraud in food related to agricultural defense.

Research addressing food defense in Brazil is found in Table 3, including: Figueira (2018), Chammem et al. (2019), Lopes, et al. (2020).

Although it has active laws and bodies, Brazil and countries such as Argentina and China usually present a lower classification regarding food quality and safety scores, even though there are internal control programs and verification of origin in commercial partner countries, for example, some members of the European Union (CHAMMEN et al., 2018). These data, if compared to the current situation of actions in food defense, unveil the vulnerability, considering the lack of national laws pertinent to intentional actions of food contamination.

According to Chammen et al. (2018), Rasff, a European platform for alerts on public health risks related to food safety, showed 23% of observed notifications corresponding to food originating from Brazil, especially meat products and seasonings containing food pathogens above the permitted limits.

Despite the relevance of the topic to strengthen the food chain, few countries have established the principles in food defense as a legal requirement, including Brazil (LOPES et al., 2020). Indeed, Brazil, when compared to major economies, presents a limited number of companies prepared to meet food defense requirements (FIGUEIRA, 2018).

Although food defense is not a legal requirement in Brazil, it has taken on an increasingly important role in Brazilian programs, notably those related to dairy products, as many of the producers need to meet foreign regulatory requirements for exports to these markets (LOPES et al., 2020).

Among the measures taken - not exactly targeted to food defense, but which can be considered as one of the first steps - is the measure of December 4, 2009 by the Chamber of Foreign Relations and National Defense of the Government Council of Brazil, which edited CREDEN Resolution No. 02/2009, in which it formulated guidelines related to intelligence activities with the following resolution:

Art. 1 Establish the following priorities for the agencies and entities integrating the Brazilian Intelligence system, which will direct their efforts, in the national and international spheres, to the areas listed below, all considered of equal relevance:

*d) biodefense of the population, and of natural and agricultural resources.
(BRASIL, 2023)

This measure, which defined guidelines to the areas of biodefense of the population and of agricultural resources, may impact the action against agroterrorism and food terrorism, making it possible to encompass the intelligence area in issues related to Food Defense. However, it is worth noting that Brazil's cultural diversity, as well as its continental size, may facilitate terrorism's access in the territory (FIGUEIRA, 2018).

3.3.3 Food Defense and the Armed Forces

Research by the Brazilian Ministry of Defense (BRAZIL, 2018) and by Mara; Mcgrath (2009), which addresses the military issue, are presented in Table 3. The supply chain is known to be long and complex, which makes a comprehensive examination of military food defense extremely difficult (MARA; MCGRATH, 2009).

After the events of September 11, 2001, the United States Armed Forces began to show more concern about intentional food contamination, with the development and implementation of methods to prevent or mitigate these actions. In the risk evaluation methodology, operational risk management is a tool developed by the medical services of the United States Air Force, with the purpose of acting in the articulation between food safety and food defense (SEVERINO; ALMEIDA, 2017).

In the USA, every military installation is required to have a food defense plan, in which the Army provides a framework for its development, and every installation must have a defense team defined and prepared (MARA; MCGRATH, 2009).

In developed nations, the goal of malicious actions against the agri-food chain is mainly to create political instability and undermine socioeconomic stability, impacting the military power (MOERMAN, 2018).

In Europe, the North Atlantic Treaty Organization (NATO) has the Allied Medical Publication (NORTH ATLANTIC TREATY ORGANIZATION, 2019): Defense Food Safety and Production Standards in Deployed Operations, which was approved by the member

nations of NATO at the Medical Standardization Council of the Military Committee. The agreement of the 28 member nations of the organization to use this publication is recorded in the Standard Agreements (Stanag), which defines processes, terms and conditions for common military-technical procedures among the alliance member nations (NORTH ATLANTIC TREATY ORGANIZATION, 2019).

In Brazil, the Ministry of Defense, following the evolution of the theme and interested in maintaining national security, included a new content in the Doctrine of Food and Nutrition of the Armed Forces - MD42-M-05, Chapter IV - Food Defense (BRAZIL, 2018). In 2019, the Chief of Logistics and Mobilization of the Ministry of Defense established the Food Defense Working Group, made up by food safety experts from the Army, Navy and Air Force, in order to draft the Food Defense Regulations of the Armed Forces (BRASIL, 2019c).

Among the actions of the group established, and as a result of the regulation prepared by the Ministry of Defense, we could mention:

- Diagnosis, mapping and evaluation of threats, defined as the ability of a malicious action to cause harm or damage to health, and of vulnerabilities, which indicates the ease that the threat has to perform a malicious action through the characterization of the target and facilities;
- Ensure that the food supply logistic chain is protected from contamination and disruption;
- Provide the mechanisms for health protection and operationality as provided in the Military Logistics Doctrine (MD42-M-02, 2016).

Food Defense measures should prioritize the operational health of the military personnel, including actions to prevent malicious contamination of food, in order to ensure health protection and military operations in Brazil and abroad.

The Brazilian Army, through a partnership with the *Universidade Federal de São Paulo* (Unifesp) and the Logistics Command (Colog) in 2020 carried out a pilot project in one of the 12 Military Regions. A Food Defense checklist was developed and applied to 24 Military Organizations (OM) located in the state of São Paulo, allowing the audited OMs to assess the degree of risk to intentional food service attacks. This article sought available data on threat evaluation and procedures in food defense in different environments. However, one limitation was the small number of available research in Brazil. Future studies evaluating the situation of food defense in Brazil are needed, proposing measures regarding the topic.

4 CONCLUSION

The current global scenario has introduced the need for greater attention to the issue of intentional food contamination. The history and existing concepts on the subject have promoted the development of threat evaluation methodologies through checklists and software, as well as procedures adopted in food defense plans. However, at the governmental level, the initiatives relevant to legislation are incipient, with the exception of the United States of America. In Brazil, where the concepts of food defense are relatively new and little researched, the Armed Forces, through the establishment of a working group assisted by its technical staff and the

partnership with Unifesp, have been working to deepen the issue, following the good practices of the global military context, which pays special attention to the subject.

Facing the countless forms of malicious actions of food contamination that, although uncommon, may have serious consequences, it is necessary to handle food defense as a national security policy, preserving the consumer's health, political and social stability, and maintaining the operational health of human resources and the Armed Forces.

AUTHORSHIP AND COLLABORATIONS

All authors participated equally in elaborating the article.

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