Defence Life Science Journal, Vol. 4, No. 4, October 2019, pp. 214-219, DOI : 10.14429/dlsj.4.14917

Implications of Biosecurity in Food Safety

Vijai Pal, N.K. Tripathi, and A.K. Goel*

DRDO-Defence Research & Development Establishment, Gwalior - 474 002, India
**E-mail: akgoel73@yahoo.co.uk*

ABSTRACT

Owing to growing population of world, efforts are being made to maximise food production. Food safety should not be compromised to meet the food requirement of increasing population. Biosecurity is the imperative approach to ensure food safety. This is a holistic approach that interlinks health, environment, security and trade. Increased incidents of foodborne diseases led to promotion of biosecurity as a major priority policy worldwide to curtail such incidents and ensure food safety. Microbial risk management is an essential component of food safety. National biosecurity programmes are essentially required to identify the prospective modes of introduction and spread of a disease in a country or region and to specify the control measures to curtail the risk associated with the disease. International standards for various biosecurity sectors are set mainly by Codex Alimentarius Commission, the World Organisation for Animal Health and Commission on Phytosanitary Measures, which are implemented through the Sanitary and Phytosanitary Agreement, 1995 of World Trade Organisation. Agricultural biosecurity is of utmost importance in the countries that are large crop and animal producers, and these countries are at risk from alien pests and pathogens. Adequate biosecurity programmes are essential in all the countries to protect global environment, agriculture and biodiversity. Developing countries, particularly with large populations aiming maximised food production require stringent biosecurity approaches to provide safe and nutritious food to the people.

Keywords: Biosafety; Biosecurity; Food safety; Food chain; Zoonosis.

1. INTRODUCTION

The term *Biosecurity* has great variability in meaning with respect to international and national laws and other documents. It is a strategic and integrated approach encompassing safety of humans, animals, plants and other useful organisms against diseases, pests and other biological factors by means of policies and regulatory frameworks in order to promote sustainable agriculture, public health, environment protection, conservation of biological diversity, regional and international trade, and economic development. Biosecurity is a holistic system covering food safety, zoonoses, transboundary introduction of diseases and pests, and release of living modified organisms (LMOs) and their products (e.g. genetically modified organisms or GMOs). International trade of agricultural products strengthens the economy of exporter country and also makes available the exotic products to the tables of transboundary consumers. Conversely it also effortlessly spreads the diseases and pests along with the agricultural products threatening the natural resources resulting in economic and environmental consequences. Importance of biosecurity has enormously increased due to parallel increase in trade of food, plant and animal products, more international travel and new outbreaks of transboundary diseases affecting animals, humans and plants. Last two decades witnessed reemergence of foodborne illness, emphasising the requirement of a coordinated regulatory system in animal and human health. Such events across the world led to evolution of new concepts in biosecurity. Biosecurity has emerged as a holistic approach interlinking health, environment, security and trade. Currently various international organisations and programmes e.g. Food and Agriculture Organisation of the United Nations (FAO), United Nations Conference on Trade and Development (UNCTAD), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), United Nations Educational, Scientific and Cultural Organisation (UNESCO), World Health Organisation (WHO), World Trade Organisation (WTO) are working on biosecurity-related issues.

Generally plant based processed food is safe for human and animal consumption. However, food processing methods and distribution systems may pose safety threats in the food chain. Food plants and consumers face a risk of natural, accidental or malicious contamination leading to disease outbreaks. Several protective measures are in place to prevent the adverse effects of such risks on the consumers. Scientific knowledge in this field has contributed enormously, particularly in prevention and control of food borne diseases and contamination of foods at all the stages of food chain. Food safety is an important aspect for international trading of food products and has become an integral part of food chain. In this ever changing world scientific community and consumers need to be vigilant in identifying emerging concerns having direct

Received : 22 February 2019, Revised : 11 June 2019
Accepted : 18 June 2019, Online published : 21 October 2019

impact on production capacity, plant biosecurity or food safety and food chain resilience. Biosecurity aspects associated with food safety in present world scenario are critically essential for easy transportation of food stuff across borders. Promotion of food safety and biosecurity has become a major policy priority worldwide to curtail the incidence of foodborne diseases. Still such incidences have increased in past few decades due to food biosafety and biosecurity associated aspects[1]. Food security cannot be ensured alone with crop yield improvement. Biosecurity guidelines to guard against perverse outcomes are critical in achieving food security.

Biosecurity can play an active role in ensuring food security through prevention of pre- and post-harvest losses resulting in crop yield protection. Biosecurity, thus can compliment crop yield improvement programmes if the gains in global farm profits are sufficient to offset the costs of its implementation and maintenance.

2. HAZARDS

Zoonotic pathogens are reemerging in humans and livestock due to globalisation[2]. Foodborne illnesses occur because of contamination of physical, chemical or microbial agents including bacteria, viruses, parasites and prions[3].

2.1 Zoonosis

Zoonosis may be defined as a disease or infection transmitted directly or indirectly between animals and humans. Worldwide zoonosis is the major cause of more than 60 per cent of infectious diseases in humans. As per a report, annually about 2.7 million human deaths are caused by 56 such zoonotic diseases[4]. Foodborne zoonotic diseases result from consumption of contaminated drinking water and food products because many of these pathogens are found in the intestine of healthy food-producing animals. Incidences of foodborne zoonotic diseases have increased drastically because of international trading and travelling, and this increase is a threat to food safety, biosecurity and public health. Majority of foodborne pathogens have zoonotic origin and healthy food animals serve as natural reservoirs and carriers of these pathogens[5]. Adequate biosecurity regulations can have better implications in reducing the incidences of foodborne illnesses.

2.2 Microbial Pathogens

Sanitary practices in food chain play a key role in determining the microbiological safety of food products. Microbial risk management covers the entire food production chain to get rid of the microbial contamination. Microbial hazards of food comprise of bacteria, fungi, protozoa, virus and prions. Bacteria and fungi under favourable environmental conditions can multiply in foods, whereas prions, virus and protozoa cannot multiply in foods[6]. Mycotoxins can be directly produced in foods by molds or can be ingested by animals excreted in food products like milk. Mycotoxins are dangerous for humans, and are resistant to heat and external influences. Bacterial toxins, however can be heat labile as well as heat resistant. Some of the foodborne illnesses include anthrax, botulism, cholera, campylobacteriosis, listeriosis, peptic ulcer, brucellosis, salmonellosis and staphylococcal food poisoning. Foodborne diseases affect 600,000,000 people and are responsible for 420,000 deaths annually as per WHO estimates[7]

Increased and indiscriminate use of antimicrobials has led to antibiotic resistance in human, veterinary, agricultural and fisheries. Food animals have become reservoirs of antibiotic resistant bacteria because of excessive use of antibiotics in modern farm industry[8]. Antibiotic resistance genes can spread from animals to humans through food chain also. Several surveillance programmes have been set up to monitor the evolution of antibiotic resistance in humans and animals[9].

Parasites to some extent also contribute to foodborne diseases. Foodborne parasite infestation is an important health hazard negatively affecting the food security and economy of society. Two third of the parasites causing foodborne illnesses are helminths and the remaining one third protozoan group. Their structural diversity and tactical biological life cycle phases enable them to survive and cause diseases[10].

2.3 Genetically Modified Organisms

GMOs are being used for crop improvement by introduction of herbicide resistance and resistance against plant diseases. According to WHO, GMOs require the specific safety assessment in terms of toxicity on human health, allergic behaviour, impact and stability of the inserted gene, and any unintended effect of the genetic manipulation. on health and environment[11]. For risk assessment of GMOs, assistance is provided by WHO Department of Food Safety and Zoonoses (FOS) to national authorities for safety evaluation. Genetically modified foods are facing challenges regarding human and environmental safety, labelling, intellectual property rights, ethics, environmental conservation, and food security[11].

2.4 Non-Microbial Hazards

Food contaminants and adulterants other than microbial hazards also compromise food safety. Mycotoxins, produced by fungi are natural contaminants and adversely affect human and animal health. The foodstuffs preferably contaminated by fungus include cereals, fruits, nuts, and meat and other products.

3. VULNERABILITIES

Natural, accidental or malicious actions in food chain or plant production systems can impose harmful impact on public health and therefore vulnerabilities and mitigation measures are conducted at different steps of food chain.

Food plants are susceptible to disease outbreakes and pest infestation which affect yield, nutritional value and food security. Water security is another natural vulnerability affecting irrigation as well as biosecurity. Natural evolutionary changes in the organisms have resulted in public health problems e.g. incidences by Shiga-toxin producing *Escherichia coli* (STEC)[12]. Human activity controls the environments to a greater or lesser extent where majority of the food plants are grown. The plant food growers aim to maximise the yield thereby increasing biosecurity and biosafety.

Storage of harvested crops under non-ideal conditions results in accidental biological contamination e.g. generation

of toxins because of fungal growth. Carelessness and poor hygiene also lead to food poisoning in preparation of regional delicacies[13]. Accidental release of plant pathogens from experimental facilities is another such vulnerability however precautions and SOPs of containment facilities may mitigate the risk. Deployment of various biosecurity measures in such installations can limit the impact of accidental release of plant pathogen or pest. Accidental outbreaks hence can be effectively managed by practicing appropriate biosecurity norms. Biosecurity largely depends on scenario but hygiene, carefulness in quality control, maintenance of records and specific risk assessment for hazards are important factors for achieving biosecurity.

Malicious attacks do occur in food/plant production but are relatively rare events. Rajneesh cult contaminated salad vegetables to affect human health of non cult voters for political gains. This event clearly demonstrated that it is very difficult and challenging to detect such covert biological contamination cases.

4. BIOSECURITY ASPECTS IN FOOD AND AGRICULTURE

Environment protection is a key determinant for health of humans, animals and plants. Different types of biosecurity threats exist for different sectors of environment and these threats can easily move from one sector to the other. Inadequate control over inter sector transfer of biosecurity threats can have impact well beyond the individual sector. Biosecurity hazards can be introduced at any step in the food chain starting from production to consumption and a biosecurity breach at any point in food chain can result in adverse health consequences to individual or multiple biosecurity sectors.

Over the years quality control systems have shifted their focus from end point testing to system and supply chain control and are oriented to implement high levels of biosecurity at all stages of food production[14].

Biosecurity abridges all methods/techniques, rules and regulations to protect a geographic region or even a single farm from infection. Generally, the farms with good biosecurity norms have a better control over disease and pathogen spread in the food chain. Therefore, it is very important to introduce National biosecurity programmes to identify the prospective modes by which diseases are introduced and spread in a region, and to specify the control measures to curtail the risk associated with the diseases[15]. The sole responsibility of actions and facilities on farm-biosecurity lies on the farmers. Farmers must implement the control measures individually in their animal holdings. Biosecurity measures comprise of three steps viz., segregation, cleaning, and disinfection[15]. Segregation involves quarantine of diseased animals and materials away from healthy animals and helps in achievement of desired biosecurity levels. Creation of barriers and their passing control help in segregation and thereby prevent spread of infections in healthy animals. Pathogens can get adhered on the surface of physical objects and equipments used on the farms hence cleaning procedures must efficiently remove most of the contaminating pathogens. Disinfection if required, is the final step after effective cleaning to achieve biosecurity, however its effectiveness in field conditions may differ from ideal conditions because organic materials in field can inactivate many disinfectants[15].

Globalisation and transboundary movements enable the food pathogens to pose a potential risk to food chain in the new regions where they never existed. Hence, adequate biosecurity management can contribute to provide maximum benefits in the international trade along with safe food[16]. Unintentional introduction of an alien biological threats to a region can prove costly and unaffordable. Furthermore, increase in food imports pose risk of transmission of zoonotic diseases resulting in disease outbreaks[17].

Biosecurity is directly concerned with food safety, biodiversity and sustainability of agriculture. Agricultural biosecurity is of utmost importance in the countries that are large crop and animal producers and these countries are at risk from alien pests and pathogens. Because biosecurity systems of developing countries are generally rudimentary, hence, agriculture in developing countries is very susceptible to terrorist attacks[18].

Agro-terrorism is an impending threat to agricultural biosecurity and involves deliberate introduction of a pathogen in areas where agriculture is being practiced[19]. Agriculture-based developing countries with large population are dependent on agriculture for their livelihood and bioterrorist attacks on crops and farm animals may damage economy and cause social panic. Famines created by such attacks could be as destructive as a biological weapon attack on human population[20]. However, agro-terrorism as a concept is largely theoretical and the frequency of such attacks is very low[21]. Moreover, beyond an actual incidence of agroterrorism, poor risk and crisis communication can cause severe damage to the economy[18].

Crops, livestocks and aquatic agro-ecosystems face a major threat of invasion by exotic pathogens, diseases and pests. Instances of agro-terrorism have never been clearly identified in India. Exotic diseases and pests affecting plants, livestock, and aquatic animals are as summarised in Table 1. Intentional or unintentional introduction of pests and pathogens in agricultural systems not only affects the economy but also threatens food security. Export restriction can also be imposed on mere exposure to a pathogen without actual incidence of disease. Thus, scientific and technological innovation can be a double-edged sword and can be deliberately used to cause harm to the agriculture[18].

India is mainly an agrarian country, and deliberate biological attack on Indian agriculture system can have enormous socioeconomic consequences because of loss of crops and animals. The Indian agriculture feeds and employ more than 54.6 per cent of the workforce and contributes around 17 per cent to the gross domestic product (GDP). Monitoring, surveillance, and control systems at the borders and in the food chain of an agricultural system determine its vulnerability to an agro-terrorist attack. India shares its land boundaries with many countries of South Asia and hence is vulnerable to introduction of diseases and pest through import of agricultural commodities. Undercover cattle trade with neighbouring countries pose a threat of epizootics if diseased animals are smuggled. Diverse agro-climatic regions predispose Indian

Table 1. Exotic diseases and pests affecting plants, livestock, and aquatic animals in India

Agricultural diseases/pests	
Fungal and Bacterial diseases	Bacterial blight of paddy (*Xanthomonas oryzae*)
	Black rot of crucifers (*Xanthomonas campestris*)
	Canker of apple (*Sphaeropsis* spp.)
	Crown gall of Apple/pear (*Agrobacterium tumefaciens*)
	Downy mildew of cucurbits (*Plasmopara cubensis*)
	Downy mildew of grapes (*Plasmopara viticola*)
	Flag smut of wheat (*Urocystis tritici*)
	Foot rot of Rice (*Fusarium moniliforme*)
	Late blight of potato (*Phytophthora infestans*)
	Powdery mildew of rubber (*Oidium heveae*)
	Powdery rust of coffee (*Hemileia coffeicola*)
	Wart of potato (*Synchytrium endobioticum*)
	Vascular wilt of oil palm (*Fusarium oxysporum* f. sp. *elaedis*)
	Soybean downy mildew (*Peronospora manshurica*)
	Tropical rust of maize (*Physopella zeae*)
Diseases caused by Virus, Viroid and Phytoplasma	Barley stripe mosaic virus
	Coconut cadang cadang (Viroid)
	Palm lethal yellowing (Phytoplasma)
Nematodes	Pine wood nematode (*Bursaphelenchus xylophilus*)
	Red ring nematode of coconut (*Rhadinaphelenchus cocophilus*)
Insects	Coffee berry borer (*Hypothenemus hampei*)
	Cotton boll weevil (*Anthonomus grandis*)
	Cottony cushion scale (*Icerya purchasi*)
	Diamond-back moth (*Plutellc xylostella*)
	Lantana bug (*Orthezia insignis*)
	Mediterranean fruit fly (*Ceratitis capitata*)
	Potato tuber moth (*Phthorimaea operculella*)
	Russian wheat aphid (*Diuraphis noxia*)
	Serpentine leaf miner (*Liriomyza trifolii*)
	Silver leaf whitefly (*Bemisia argentifolii*)
	Woolly apple aphid (*Eriosoma lanigerum*)

Animal pests/diseases	
Bacterial/viral diseases	Avian influenza (poultry)
	African swine fever (pigs)
	Blue tongue (sheep, domestic and wild ruminants)
	Classical swine fever (swine)
	Foot-and-mouth disease (cattle, pigs, sheep, goats, water buffalo)
	Lumpy skin disease (cattle; Capri poxvirus)
	Sheep and goat pox (sheep, goat; Capri poxvirus)
	Peste des petits ruminants (goats, sheep)
	Rift valley fever (sheep, cattle, goats)
	Rinderpest (cattle, domestic buffalo; rinderpest virus)
	Swine vesicular disease (swine; enterovirus)
	Vesicular stomatitis (horses, cattle, pigs)
	Cholera (*Vibrio cholerae* O139)
	Plague (*Yersinia pestis*)
	Nipah Virus

Aquatic animal pest/diseases	
Viral diseases	Abdominal segment deformity disease (ASDD) of whiteleg shrimp
	Cyprinid herpesvirus 3 or Herpes virus of Koi (climbing perch) and common carp
	Infectious myonecrosis virus (IMNV) of whiteleg shrimp
	White spot syndrome virus (WSSV) of shrimp
	Yellow head virus (YHV) of shrimp
Fungal diseases	Epizootic ulcerative syndrome or red spot disease of fish (*Aphanomyces invadans*/*A. piscicida*)

agriculture to establishment of exotic pests and pathogens resulting in substantial agricultural loss. In Indian federal system states are individually responsible for protection against pests and diseases, and infrastructure and expertise to manage the losses caused by exotic pests and disease varies from state to state. Export restriction on agriculture-dependent countries due to minor outbreaks of exotic diseases or pest in crops and animals can have severe economic consequences.

Threats and vulnerabilities of agro-terrorism can be effectively addressed by developing a comprehensive strategy and a combined interagency approach. The level of preparedness of agricultural sector for disease outbreaks can be increased by developing new technologies pertaining to civilian application in agriculture, detection, protection, and prophylaxis, and by upgrading laboratory facilities. New generation technologies like biosensors/biochips, microarray-based diagnostic kits, rapid detection technologies, nanobased detection kits and field based portable diagnostic and detection systems would facilitate accurate and sensitive detection of plant pathogens and have direct or indirect relevance in achieving agricultural biosecurity.

5. BIOSECURITY- INTERNATIONAL STAKEHOLDERS

International standard setting bodies including the Codex Alimentarius Commission (CAC), the World Organisation for Animal Health (OIE), and Commission on Phytosanitary Measures (CPM) set up the standards for various biosecurity sectors according to their mandates. The technical standards set by these bodies do not have any direct legal binding. However, standards of CAC, OIE and CPM are recognised by Sanitary and Phytosanitary Measures (SPS) Agreement, which is an international treaty of World Trade Organisation (WTO) entered into force in 1995[22]. Through this agreement, each member-state is obliged to follow policies related to food safety and plant and animal health with respect to imported pests and diseases. At international level different organisations and bodies share the responsibilities for different sectors of biosecurity. FAO plays a major role in implementation

of biosecurity approach, and hosts Secretariat for the CAC and International Plant Protection Convention (IPPC). FAO organises expert and technical consultations on biosecurity, supports capacity building, and operates International Portal on Food Safety, Animal and Plant Health to facilitate the exchange of information. FAO also facilitates collaboration between the three SPS-recognised standard-setting bodies i.e. CAC, OIE and CPM, the World Bank, WHO and WTO.

WHO helps countries in prevention, detection, and verification of epidemic-prone and emerging diseases. It collaborates with States Parties in evaluation of their public health capacities. Several other international legal instruments, agreements and texts including the SPS Agreement, the agreement on Technical Barriers to Trade (TBT) Agreement, the Convention on Biological Diversity (CBD) and its Cartagena Protocol on Biosafety, and the International Health Regulations are also relevant to biosecurity.

6. BIOSECURITY – INDIAN SCENARIO

India has a plethora of laws regarding biosecurity, and over the years different systems are in place for protection of plants, animals and marine health. Different institutions throughout the country serve to meet the objectives of original enactments. Bacterial, viral and fungal pathogens, and insects and nematodes pose serious threat to plant health and lead to collapse of food production. Destructive Insects and Pests Act, 1914 (DIP Act, 1914) enforced plant quarantine regulations through 35 plant quarantine stations of the Directorate of Plant Protection, Quarantine and Storage (DPPQ&S) of the Department of Agriculture and Cooperation (DAC). Several amendments through notifications have been made from time to time in DIP act, 1914. Quarantine of all plant germplasm and transgenic planting material is undertaken by the National Bureau of Plant Genetic Resources (NBPGR). NBPGR station at Hyderabad handles the export samples of International Crop Research Institute of Semi-arid Tropics (ICRISAT). Integrated Pest Management (IPM) through 31 Central Integrated Pest Management Centres (CIPMCs) has also been in place since 1985 for plant protection. Livestock Importation Act, 1898 monitors the import of livestock and livestock products through international ports at Delhi, Mumbai, Kolkata and Chennai. Import of aquatic animals is regulated by Land-border check-post at Petrapole (West Bengal) and sea-ports at Kochi and Vishakhapattinam under the Department of Animal Husbandry, Dairying and Fisheries (DAHD&F). Environment Protection Act (EPA) of 1986 regulates the Genetically Modified Organisms (GMOs). A National Certification System for Tissue Culture Raised Plants (NCS-TCP) under 'Seed Act 1966' was established in 2006 by Department of Biotechnology (DBT) in order to ensure pathogen and pest free production and distribution of quality tissue culture planting material.

Destructive Insects and Pests Act, 1914 and the Livestock Importation Act, 1898 were very old and under these legislations quarantine officers were not having powers to destroy or confiscate the consignment or lodge complaints under the Indian Penal Code. Hence, there was a need to introduce a new biosecurity approach in India meeting all the obligations of international trade and SPS agreements. The National Policy for Farmers (2007) aimed to strengthen the biosecurity of crops, farm animals, fish, and forest trees for safeguarding the livelihood and income security of farmer families and the health and trade security of the nation as a major policy goal. It was also recognised that an integrated national biosecurity system covering plant, animal and marine issues needs to be established to meet the biosecurity requirements. The Agricultural Biosecurity Bill, 2013 was introduced in Lok Sabha on 11th March, 2013, in India. The Bill proposed for the establishment of Agricultural Biosecurity Authority of India (ABAI) to protect plants, animals and related products from pests and diseases to ensure agricultural biosecurity. However, the bill was criticised for not addressing the concerns of epizootics/zoonoses, disease causing organisms that can transmit from one vertebrate to another, and the domestic quarantine[23]. The Agricultural Biosecurity Bill, 2013 that was pending in the parliament has now lapsed.

7. CONCLUSION

Adequate biosecurity programmes are essential in all the countries to protect global environment, agriculture and biodiversity. Networking is needed for spreading the information and to increase the mutual understanding of working practices across countries to guarantee food safety and biosecurity. Efforts need to be made to augment the international trade by reducing the risk through biosecurity policies. Effective and efficient biosecurity models have appeared in countries like New Zealand, Australia and USA. However in India collective efforts are required by R&D organisations under ministries of Agriculture, Environment and Forests; Food Science and Technology, Home Affairs, Commerce and Industry, and Defence to make it bio-secure.

REFERENCES

1. Rodriguez-Lazaro, D.; Cook, N. & Hernandez, M. Real-time PCR in food science: PCR diagnostics. *Curr. Issues Mol. Biol.,* 2013, **15**, 39-44.
2. Glik, D.C. Risk communication for public health emergencies. *Annu. Rev. Public Health,* 2007, **28**, 33-54 doi: 10.1146/annurev.publhealth.28.021406.144123.
3. Newell, D.G.; Koopmans, M.; Verhoef, L.; Duizer, E.; Aidara-Kane, A.; Sprong, H.; Opsteegh, M.; Langelaar, M.; Threfall, J.; Scheutz, F.; van der Giessen & J.; Kruse, H. Food-borne diseases - the challenges of 20 years ago still persist while new ones continue to emerge. *Int. J. Food Microbiol.,* 2010, **139** Suppl 1, S3-S15 doi: 10.1016/j.ijfoodmicro.2010.01.021.
4. Grace, D.; Mutua, F.; Ochungo, P.; Kruska, R.; Jones, K.; Brierley, L. Mapping of poverty and likely zoonoses hotspots. Zoonoses Project 4. Report to the UK department for international development. Nairobi, Kenya: ILRI, 2012.
5. Collins, J.D. & Wall, P.G. Food safety and animal production systems: Controlling zoonoses at farm level. *Rev. Sci. Tech.,* 2004, **23**(2), 685-700.
6. Untermann, F. Microbial hazards in food. *Food Control,* 1998, **9**(2), 119-126. doi: 10.1016/S0956-7135(97)00067-4.

7. Havelaar, A.H.; Kirk, M.D.; Torgerson, P.R.; Gibb, H.J.; Hald, T.; Lake, R.J. ; Praet, N.; Bellinger, D. C.; de Silva, N. R.; Gargouri, N.; Speybroeck, N.; Cawthorne, A.; Mathers, C.; Stein, C.; Angulo, F. J. & Devleesschauwer, B. World Health Organisation global estimates and regional comparisons of the burden of foodborne disease in 2010. *PLoS Med.,* 2015, **12**(12), e1001923. doi: 10.1371/journal.pmed.1001923.
8. Guardabassi, L.; Schwarz, S. & Lloyd, D.H. Pet animals as reservoirs of antimicrobial-resistant bacteria. *J. Antimicrob. Chemother.,* 2004, **54**(2), 321-332. doi: 10.1093/jac/dkh332.
9. Hanon, J.B.; Jaspers, S.; Butaye, P.; Wattiau, P.; Meroc, E.; Aerts, M.; Imberechts, H.; Vermeersch, K. & Van der Stede, Y. A trend analysis of antimicrobial resistance in commensal *Escherichia coli* from several livestock species in Belgium (2011-2014). *Prev. Vet. Med.,* 2015, **122**(4), 443-452. doi: 10.1016/j.prevetmed.2015.09.001.
10. Gajadhar, A.A. Introduction to foodborne parasites. Foodborne parasites in the food supply web: Occurrence and control. Cambridge, United Kingdom: Woodhead Publishing, 2015;3-9.
11. World Health Organisation (WHO). Food Safety. Frequently asked questions on genetically modified foods. http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/. 2014.
12. Karch, H.; Denamur, E.; Dobrindt, U.; Finlay, B.B.; Hengge, R.; Johannes, L.; Ron, E. Z.; Tonjum, T.; Sansonetti, P. J. & Vicente, M. The enemy within us: Lessons from the 2011 European *Escherichia coli* O104:H4 outbreak. *EMBO Mol. Med.,* 2012, **4**(9), 841-848. doi: 10.1002/emmm.201201662.
13. Garcia, R.A.; Hotchkiss, J.H. & Steinkraus, K.H. The effect of lipids on bongkrekic (Bongkrek) acid toxin production by *Burkholderia* cocovenenans in coconut media. *Food Addit. Contam.,* 1999, **16**(2), 63-69.
14. Heres, L.; Hiller, A.; Althoff, G.S. & Urlings, B. Risk-based innovations in food safety management. In: Petersen B, Nüssel M, Hamer M, eds. Quality and risk management in agri-food chains: Wageningen academic publishers, The Netherlands, 2014;175.
15. Madec, F.; Hurnik, D.; Porphyre, V. & Cardinale, E. Good practices for biosecurity in the pig sector: issues and options in developing and transition countries. Food and agriculture organisation of the United Nations (FAO) Rome, Italy, 2010. 89
16. Sharma, S.B. & Wightman, J.A. Biosecure global food value chains. Vision infinity for food security: Springer International Publishing AG, Cham, Switzerland, 2015;37-47.
17. Gould, L.H.; Kline, J.; Monahan, C. & Vierk, K. Outbreaks of disease associated with food imported into the United States, 1996-2014(1). *Emerg. Infect. Dis.,* 2017, **23**(3), 525-528. doi: 10.3201/eid2303.161462.
18. Anand, M. A systems approach to agricultural biosecurity. *Health Secur.,* 2018, **16**(1), 58-68. doi: 10.1089/hs.2017.0035.
19. Monke, J. Agroterrorism: Threats and preparedness. CRS report for congress No. RL32521. Washington, DC: Congressional research service, 2004.
20. Whitby, S. & Rogers, P. Anti-crop biological warfare: implications of the Iraqi and US programs. *Def. Anal.,* 1997, **13**(3), 303-318.
21. Parker H. Agricultural bioterrorism: A federal strategy to meet the threat. McNair paper 65 institute for national strategic studies, National Defense University Washington, DC, 2002.
22. Melvin, S. The SPS agreement and biosafety. FAO Legal Paper Online #65. WTO, 2007.
23. Manupriya. India's biosecurity regulations face criticism. *Nature India*, 2014.

ACKNOWLEDGEMENT

The authors are thankful to Director, DRDE, Gwalior for his keen interest, constant support and providing necessary facilities for this study (Acc no. DRDE/BPT/26/2019).

CONTRIBUTORS

Dr Vijai Pal did his MSc(Biotechnology) from CCS Haryana Agricultural University Hisar in 2000 and PhD from Jiwaji University, Gwalior in 2016. Presently, he is working as Scientist 'E' at DRDO-Defence Research and Development Establishment, Gwalior on development of diagnostic/detection systems for biothreat agents. He has published more than 30 research paper in Journals, besides one book and has filed one Indian Patent.
He contributed in literature collection and compiling.

Dr Nagesh Tripathi received his PhD (Chemical Engineering) from National Institute of Technology, Rourkela. Presently, he is working as Scientist 'D' at the DRDO-Defence Research and Development Establishment, Gwalior. His research interest includes scale up of biomolecules including recombinant proteins, activated carbon spheres and development of chemical protective suit.
He contributed in literature collection and compiling.

Dr Ajay Kumar Goel received his PhD (Microbiology) from CCS Haryana Agricultural University, Hisar, in 1999. Currently working as a Scientist 'F' and Head, Bioprocess Technology Division, DRDO-Defence Research and Development Establishment, Gwalior. He has more than 100 research paper, 6 patent, radio talks, books and several overseas presentations to his credit. His current research interest includes development of detection and protection systems for potential biothreat agents.
He provided overall guidance in writing the manuscript