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Ensuring On-farm Food Safety through Good Agricultural Practices: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

With food-borne illnesses increasing every year and e-commerce operations reaching every location globally, ensuring food safety is of paramount importance. In India, 16 per cent of the total disease outbreaks are reported to be food-related emphasising the significance. While On-Farm Food Safety (OFFS) practices ensure food safety, many complexities are involved in bringing them to the forefront among farmers due to underreporting of food-borne illness, small and scattered farms, lack of evidence in linking illness to food consumed etc. Tackling OFFS requires farmers to adopt Good Agricultural Practices (GAPs) that address environmental, economic and social sustainability. India also offers a certification scheme, IndGAP, to individual and group farmers that

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requires farmers to follow GAPs. Though the scheme is available, its adoption among farmers is yet to be ascertained due to a lack of data. Implementation of GAPs by farmers reportedly reduces the consumption of plant protection chemicals thereby reducing the cost of cultivation. As compliance with various such practices that ensure food safety is required, the food produced by the farmers following GAPs will be much safer than otherwise. Evidence also suggests that both small and large farmers have similar levels of knowledge on various GAPs and thereby any farmer can implement them with handholding support from the governments. As most of the landholdings in India are small and marginal, Farmer Producer Organisations should be leveraged to train the farmers in the adoption of GAPs. More research on OFFS practices adoption levels, cost and return analysis and improving the regulations and compliance in the policy landscape of food safety are essential to ensure food produced is safe to consume.

Keywords: Good Agricultural Practices (GAPs); farmer producer organisations; IndGAP; On-farm Food Safety (OFFS).

1. INTRODUCTION

Food-borne illnesses are becoming more common as a result of globalization in agriculture and the growth of e-commerce in the agriculture sector, wherein customers are buying farm-fresh produce directly from farmers (Odo et al., 2021)

Unsafe foods are reported to cost India around 15 billion dollars annually, and the burden magnitude is comparable to that of malaria/HIV/tuberculosis (WHO, 2020). Also, one out of every 10 people globally are getting ill due to various food-borne disease illnesses. All the above points underscore the importance of ensuring food safety to have a healthy and sustainable life. The sustainable development goals of the United Nations further corroborate the aspect of ensuring food safety with the presence of food safety aspects in multiple of its goals. Goals 2 (zero hunger), 3 (good health and wellbeing), 6 (clean water and sanitation), and 12 (sustainable production and consumption) have various aspects dealing with food safety.

Food safety deals with ensuring that the food people consume is completely safe and free of any kind of contamination, including microbial, parasitic or chemical contamination (Jaisridhar et al. 2024, Bandara et al. 2021). While on-farm food safety deals with practices and measures implemented at the farm level to ensure that food products are safe for consumption (Ehuwa et al., 2021; Gizaw, 2019). Farmers follow various practices during the cultivation process which pose a threat to the safety aspects of food. Chen et al., (2021) in their work on producers' knowledge of On-Farm Food Safety (OFFS) practices reported many lags in the knowledge of farmers that can lead to health hazards. They revealed that majority of the farmers do not recognise irrigation water as a source of pathogens and 27-40 per cent of the farmers reportedly tested their water used in irrigation. Farmers also overuse pesticides, apply unsafe manures, and follow unsafe storage and handling practices which are widely reported to result in foodborne diseases.

2. TYPES OF FOOD-BORNE HAZARDS

According to World Health Organisation (2020) food-borne hazards are classified into 3 types namely biological, chemical and physical hazards. Biological hazards are those hazards which are caused by the presence of living organisms in the food that we consume. Some of the major biological hazards include *Salmonella sps, Clostridium botulinum, Campylobacter jejuni* etc. The presence of these organisms in the food causes various food-borne illnesses ranging from diarrhoea to death. Chemical hazards are caused due to presence of various chemicals that are potential threats to the well-being of human beings. During agricultural production, farmers use a wide range of chemicals such as fertilisers, pesticides, insecticides, plant growth hormones etc., which when used more than the necessary amount can cause illness when consumed by humans. Also, producing food in industrial areas, and improperly drained areas can result in the accumulation of heavy metals in the food resulting in diseases. Physical hazards include the presence of physical materials in the food such as stones, glass, dust etc (Al-Seghayer & Al-Sarraj, 2021 and Singh & Singh, 2024). These hazards occur primarily because of lax implementation of safe harvesting and post-harvest practices.

3. FOODBORNE DISEASE SURVEILLANCE IN INDIA

In India, the Ministry of Health and Family Welfare is the apex organisation dealing with foodborne diseases. Since 2004, it is implementing a programme Integrated Disease Surveillance Project (IDSP) which monitors and reports all disease outbreaks in India. It covers all the disease outbreaks including foodborne diseases. It reports weekly. According to Bisht et al., (2021), out of all the disease outbreaks in India, 16 per cent of them are food-related diseases emphasizing the substantial amount of food-related diseases in India. Also, acute diarrheal disease is reportedly adding to 26 per cent of the total disease outbreaks in India. It is well known that food that is consumed also plays a role in diarrhoea. Fig. 1 shows that among the foodborne diseases, the majority of them arise from grains and beans followed by fruits and vegetables. All these numbers are only that are being reported by the hospital networks of India. Apart from these many of the diseases are getting not reported due to mild symptoms caused by food.

Bisht et al., (2021) also reported the number of outbreaks, illness and deaths due to foodborne diseases from 2009 to 2018 based on reports of IDSP. During the same period, a total of 2,688 outbreaks of foodborne diseases were reported with 1,53,745 people getting ill and 572 persons dying due to the illness. On average, every year, 269 outbreaks, 15,375 people get ill and 57 deaths occur due to foodborne diseases. These diseases have huge economic consequences on people. Firstly, ill persons need to incur expenditure for care which will further reduce their net incomes. People will also lose their income as they can not report to work during the illness period. The productivity of people will be reduced due to illness. In the worst consequence, illness may result in death leading to insurmountable consequences to the family depending on the person.

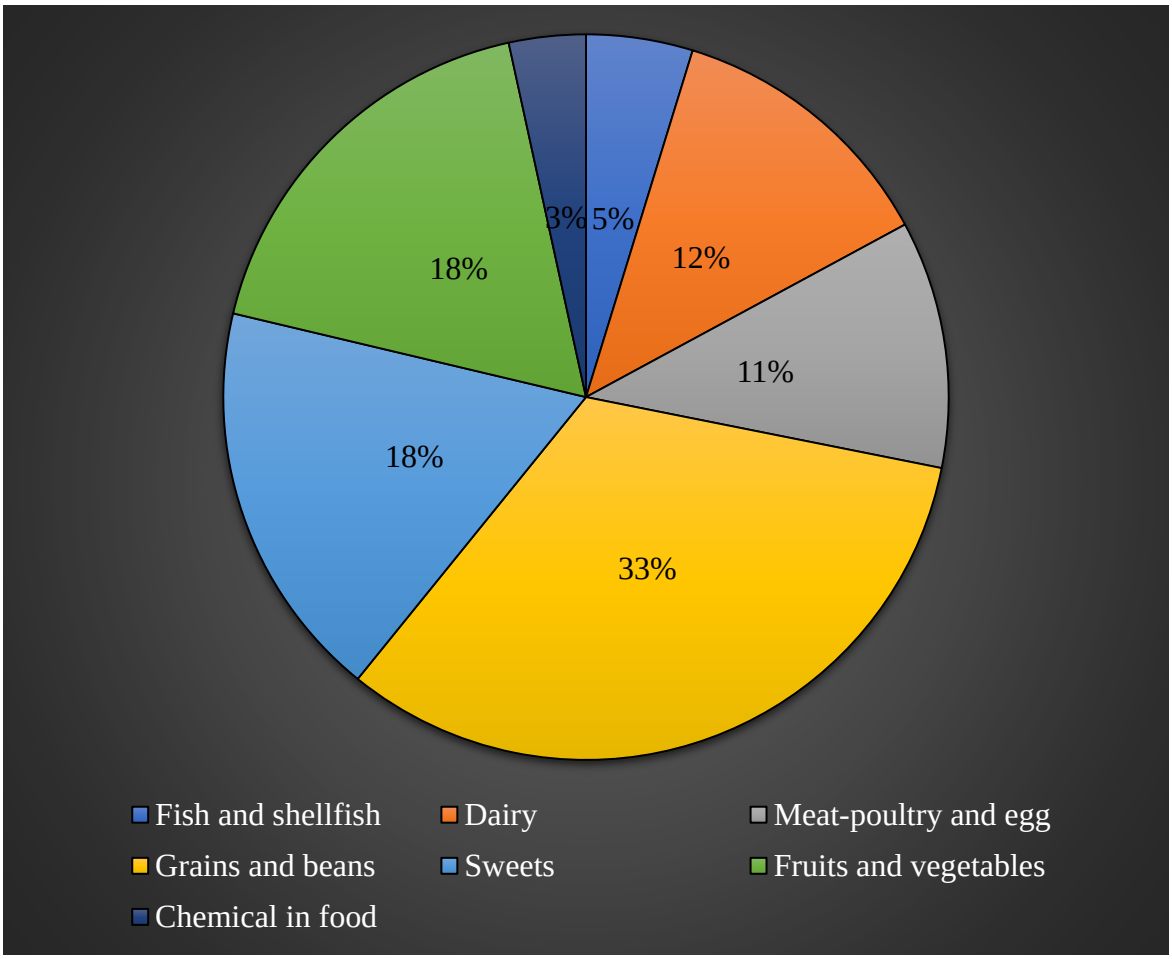

Fig. 1. Distribution of percentage of food-borne outbreaks in India

Though reporting of diseases is done through IDSP, the Food Safety and Standards Authority of India (FSSAI) is also involved in addressing foodborne diseases. FSSAI conducts uninformed checks on foods being consumed by people by checking whether the foods are conforming to the standards prescribed. According to the Food Safety and Standards Authority of India, every year around 30 per cent of the samples analysed are found to be non-conforming to the standards as shown in Fig. 2. This shows the need to improve the implementation of safe food production practices.

Anti-microbial resistance is another leading food safety aspect that results from the overuse of antimicrobials in animal food production. This overuse results in increased resistance of microbes to antimicrobials making diseases uncurable. It is also reducing farm productivity and thereby threatening food security. As per the World Health Organisation (2020), in USA, Australia and Eurpoe, 75 per cent of the total antibiotics produced are reported to be used in the agricultural sector alone. Bacterial antimicrobial resistance has also reportedly led to 1.27 million global deaths in 2019 alone. All these call for improving the safety aspect in allied sectors of agriculture too.

4. COMPLEXITIES IN ENSURING ON-FARM FOOD SAFETY (OFFS)

Lack of proper evidence and underreporting is the major constraint in ensuring OFFS. As many of the disease symptoms are mild, people don't seek medical support and thereby underreporting of the incidences occurs (Rai et al., 2024; Jagadeesan et al., 2019). Functional surveillance systems for foodborne diseases in India are also still underdeveloped. Studies highlighting the burden of foodborne diseases are also lacking in India. This lack of scientific evidence hinders the implementation of new policies and practices for ensuring OFFS (Hassan & Fweja, 2020; Bhavaniramya et al., 2019). Currently, policies regulating food safety are widely present only in the products destined for export. Thereby a shift to the domestic market is essential to ensure the health of our population. The presence of small and scattered farms in India is also a major hindrance as the implementation of OFFS practices does not lead to the scale of economy (Nath & Gohain, 2024; Rezaei & Mianaji, 2019). Also, agricultural marketing in India primarily occurs through informal markets wherein farmers and traders pool the produce before selling it to retailers. This makes it very difficult to monitor and reporting of foodborne hazards. Finally, there is on one size fit all approach in food safety systems internationally as food systems vary from country to country and even within the country.

5. FARMERS' DUAL ROLE IN FOOD SAFETY

Farmers play a dual role in food safety as they are both producers as well as consumers. In India, around 54 per cent of the total workforce is employed in agriculture and its allied sectors. Thereby, more than half of the national population is involved in both production and consumption activities. But, Xiaxia and Yunxi (2018) reported that there is a disconnect in the roles of farmers as producers and farmers. As consumers, farmers as an individual and families concerned want safe and hygienic food while as producers they are not ensuring that the food they produce is safe. This is due to various reasons such as market demand, economic reasons etc. To ensure food produced on farms is safe, there is a need to establish connect between their roles as producers and consumers making them accountable and responsible for the food they produce.

6. GOOD AGRICULTURAL PRACTICES (GAPS)

GAPs are voluntary on-farm food safety practices that are followed by producers to ensure the food produced on their farms is safe and sustainable (Schmit et al, 2020). These are the practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products. They are underlined by four pillars namely economic viability, environmental sustainability, social acceptability and food safety and quality assurance (Poisot et al, 2007). All the GAPs should be inclusive of these four pillars.

In the USA, there is a rule namely the Producer Safety Rule which mandates farmers to follow GAPs as per the Food Safety Modernisation Act of 2011. Farmers are also provided with a compulsory training programme in GAPs to comply with and implement them. Though it is mandatory for all producers, there is a qualified exemption for small farmers under the act based on income and farm size. However, it is reported that even small farmers are implementing GAPs as the traders and consumers are demanding

such produce. While India does not have such kind of legislation mandating farmers to follow GAPs, there is a certification scheme available for farmers namely IndGAP to certify the produce.

7. IndGAP

IndGAP stands for India Good Agricultural Practices, a certification scheme offered by the Quality Council of India (QCI) for the farmers of the nation. Quality Council of India is an autonomous organisation working under the Ministry of Commerce and Industry since 1996. The certification prescribes certain practices that need to be followed by the farmers during their production process which ensures that the food which is produced is safe and sustainable. All the standards prescribed under the IndGAP certification are also aligned with the ISO 17065 standards for product/process certification, thereby making them valid internationally.

7.1 IndGAP Basic, IndGAP Premium and Group Certification

In India, small and marginal farmers constitute around 86% of the total farmers, who frequently lack sufficient land and resources to implement the recommended practices. Keeping this in mind, QCI is offering two different schemes, one catering to small and marginal farmers while the other for large farmers. IndGAP Basic is the certification scheme for small and marginal farmers. Importantly, the scheme also has a provision for tenant/lease land farmers. These landless farmers must have a documented agreement with the landowner stating that the latter has no power over the production process or products produced on the land. IndGAP Premium is a scheme aimed at large farmers (Quality Council of India, 2024).

The scheme also has a provision for group certification and the certificate will be issued in the name of the group. All the registered Farmer Producer Organisations (FPOs) can avail the benefits of this certification scheme, opening avenues for them to access new markets. As small and marginal may often feel hindered by the certification charges and also lack essential knowledge and training on Good Agricultural Practices, FPOs can play a key role. As per the Economic Survey 2023-24, 8,195 FPOs are registered in India and the government is further working to increase their number and presence throughout the country. FPOs can play a significant role in increasing the number of farmers who have this certification by offering education and training to all farmers in the group on the practices that must be followed to obtain this certification.

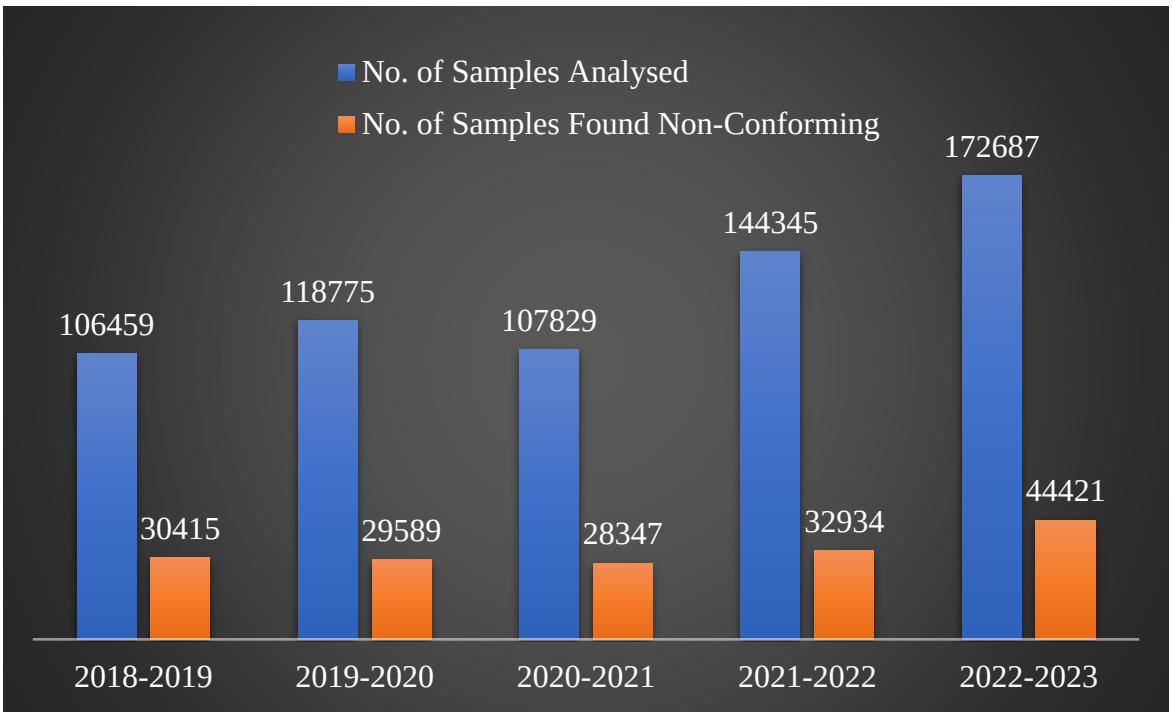

Fig. 2. Analysis of food samples under Food Safety and Standards Authority of India (FSSAI) rules

7.2 Overview of the Certification Process

A farmer or farmer group needs to register and apply for the certification to certification bodies (CB) which involves providing all the relevant information about the crop, location, area, etc. Following the application process, the CB will verify and inform the farmers within 7 days if any deficiencies are observed. If the information is found to be complete, the application will be accepted. Following that, farmers can seek a non-mandatory pre-assessment to assess their preparedness and the presence of required documents and records. Later, an initial evaluation by the CB will be done. Following that, both announced and unannounced audits (10% of the applicants) will be done in the later stages by the CB. Assessment will be done based on the Control Points and Compliance Criteria checklist, which is a list of all various practices that the farmers need to follow in the production process. There are 3 different compliance criteria which are under this scheme, namely, Major, Minor and Recommended. Farmers should comply 100 per cent with the Major criteria, 95 per cent of the Minor criteria, and no minimum compliance is required in case of Recommended criteria. Once the farmers are found to be complying with the practices, certification will be granted on the name of the farmer along with the name of the produce, validity date etc. The certificate will be valid only for 12 months with a provision for extension for a maximum period of 4 months given valid reasons as acceptable by the CB. The certification can be renewed at the end of each year given that the farmers is continuously following all the practices as required.

8. ADVANTAGES OF OFFS PRACTICES

Produce with the IndGAP certification guarantees that it is grown sustainably and safely, opening up new markets for the product, including retail stores and online retailers. Also, because the standards satisfy the demands of foreign importers, it makes our produce export-ready and comply with non-tariff trade barriers. Farmers can realize higher prices for their products, especially through group marketing by utilising the FPOs in the region. As the farmers are mandated to follow good agricultural practices, it ensures environmental and social sustainability. Overall, it also guarantees that the food produced is safe for consumption and free of any contamination which threatens human health.

Following OFFS practices is also widely reported by the scientific community to enhance food safety and also to reduce the use of chemicals applied. Kulic et al (2021) in their work compared the technical perspectives of conventional farmers and farmers following OFFS practices. Table 1 revealed that farmers using GAPs used lower quantities of fertilizers, insecticides, fungicides, and herbicides, i.e., 31.3%, 50%, 25%, and 30%, respectively, than conventional farmers.

The evidences from the study indicate that by implementing OFFS practices, farmers can reduce input usage by substantial amounts thereby reducing their production costs which ultimately offset price deficiency due to lower yields (Xianxia and Yunxi 2018).

While it is often perceived that small farmers may lack financial resources and also human capital to avail such certification expenses and implementation bottlenecks, research evidences point out some positive prospects. Parket et al (2016) in their work on differences between small and large-scale farmers in knowledge and implementation of OFFS practices studied a total of 116 variables affecting food safety. Results revealed that only 10 per cent of the variables are found to be showing evidence of scale of relationship between small and large farmers. Also, growers of all farm sizes had similar levels of knowledge of OFFS practices to prevent contamination. They have also grouped variables and performed ANOVA analysis, and found that small and medium farmers were more perceptive of pre and post-harvest field risks than large growers.

Table 1. Comparison of input usage among OFFS farmers and conventional farmers

	Conventional farmers	GAP farmers
Fertilizer	142.3 kg/ha	99 kg/ha
Insecticide	0.8 kg/ha	0.4 kg/ha
Fungicide	0.4 kg/ha	0.1 kg/ha
Herbicide	0.1 kg/ha	0.07 kg/ha

Studies also reported various factors that act as motivation and barriers among farmers for implementing OFFS practices. Under motivating factors, meeting consumer requirements and certifications was the primary factor followed by the feeling of responsibility of producing safe food. Under barriers, the burden of compliance costs followed by lack of time for implementing OFFS practices, lack of knowledge and lack of returns were identified (Chen et al., 2021).

9. CONCLUSION

It is evident that there is an increasing trend in food-borne illness which calls for significant improvements in the food safety regulations landscape of India. With the increase in e-commerce operations and the opening up of global agricultural trade, it is very essential to ensure the safety of the food produced so as to hold a firm hand in the global trade. As the advantages of GAP practices are established, further promotion of such practices is vital to ensure food safety. Also, research studies revealed that even small farmers can benefit from the implementation of OFFS practices. Such practices also address the sustainability aspects which are very essential in the context of climate change. Currently, there is a lack of studies in India regarding the adoption of IndGAP, costs and return analysis of GAP implementation hinders evidence-based policy formulation. Social science researchers can conduct more research on OFFS practices awareness, adoption and perception of farmers. More education and training for farmers and other stakeholders should be provided. Information and education materials for information dissemination should be designed and provided by the extension personnel. Policy advocacy regarding the policies supporting the implementation of OFFS should be done to promote their implementation. Convergence in the role of farmers' as consumers and producers should be achieved by influencing their attitudes and behaviour. This will ensure farmers to be accountable and responsible for the food they produce. Also, FSSAI's focus on post-harvest surveillance should be moved to pre-harvest OFFS practices too. FPOs can also be leveraged by scaling them up technically to educate the farmers under them to follow OFFS practices and avail the benefits of the group certification scheme offered by IndGAP.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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